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Three Papers on Fossil Insects, and the British and Foreign Formations in which Insect Remains have been detected.

No. 1.

THE INSECT FAUNA

OF THE

RECENT AND TERTIARY PERIODS.

(Read before the Geologists' Association on the 1st June, 1877).

BY

H. GOSS, F.L.S., F.G.S., &c.

Reprinted from "PROCEEDINGS OF THE GEOLOGISTS' ASSOCIATION," VOL. V., No. 6.

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THE INSECT FAUNA

OF THE

RECENT AND TERTIARY PERIODS,

AND THE

BRITISH AND FOREIGN FORMATIONS OF THOSE PERIODS IN WHICH INSECT REMAINS HAVE BEEN DETECTED.

By HERBERT GOSS, F.L.S., F.G.S., F.Z.S., &c.

Introduction.

In the following paper I shall endeavour to call the attention of this Society to an interesting and important branch of Palæontology, which, until a comparatively recent date, had received but little notice, either in this country or on the Continents of Europe or America.

There can be no doubt of the importance of an acquaintance, on the part of the Geologist, with the insect fauna of former times; for when we consider that insects are inhabitants not only of the air and the land, but also of the water,[1] it is obvious that a study of their remains must be of the greatest value in assisting us to arrive at just conclusions as to the geological conditions of the Earth in past ages.

[1] *i.e.*, Fresh water.

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The investigations and discoveries of [1]Professor Oswald Heer, of Zurich, have shown that the study of fossil insects, and a comparison of the numerical proportion existing between the *carnivorous* and *herbivorous* classes of any former period, with that existing at the present day in various parts of the world, between the same classes, cannot fail to throw much light on the nature of the vegetation and climate prevailing during former Geological epochs. The testimony of so eminent a Geologist as Sir Charles Lyell, to the valuable deductions which may be drawn from a study of fossil insects, is too important not to be here referred to. In his "Elements of Geology,"[2] Sir Charles observes that, "the characters of many of the insects" (*i.e.*, the fossil insects of Œningen) "are so well defined, as to incline us to believe that if this class of the invertebrata were not so rare and local, they might be more useful than even the plants and shells in settling chronological points in Geology."

The fossil remains of the Vertebrata, the Mollusca, and the Crustacea, have all been carefully studied; but notwithstanding the evident importance of fossil Entomology, it is only in comparatively recent times, that the *Insecta* have begun to receive attention. M. Emile Oustalet, after alluding to the amount of attention bestowed on the other divisions of the Animal Kingdom, observes, that although reference had been made as early as the beginning of the Eighteenth Century [3] to "*Entomolithes*," it was not until 1839 [4] that M. Brullé, in an inaugural address to the "Faculté

[1] "Die Insekten-fauna der Tertiärgebilde von Œningen und von Radoboj in Croatien, Leipzig, 1847-1853; Untersüchungen über das Klima und die vegetations Verhältnisse des Tertiärlandes," 1860; and a translation of the same into French by Dr. Ch. Gaudin, 1861. Die Urwelt der Schweiz, 1865, and an English translation by Mr W. S. Dallas, F.L.S., edited by Mr. Heywood, F.R.S.

[2] "Elements of Geology," 6th edition, p. 255.

[3] Signor Massalongo observes, "Fino dal principio del secolo xviii. s'ebbe contezza di insetti petrificati in varie parti d'Europa; ed il Scheuchzer prima e quindi il Sendelius furono forse i primi che ci abbiano tramandate notizie di qualche importanza sopra questi esseri." Studii Paleontologici. Verona. 1856. p. 11.

[4] "Depuis la vigoureuse impulsion donnée par Cuvier à la Paléontologie les Mamifères, les Oiseaux, les Reptiles, les Poissons, les Crustacés, et les Rayonnés eux-mêmes, aussi bien que les végétaux, ont été l'objet de travaux considérables qu'il serait impossible d'énumérer ici. Seuls les insectes ont été négligés pendant fort long temps, quoique dès le commencement du

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des Sciénces de Paris,"[1] called attention to the interest which might be derived from the study of fossil Insects.

It must not, however, be supposed from the foregoing observations, that this branch of Palæontology had received literally no attention whatever, prior to 1839. Reference is made to fossil insects as long ago as 1700, in Scheuchzer's "Herbarium Diluvianum;"[2] and Marcel de Serres states that Linnæus[3] gave the name of "*Entomolithes*" to those petrifications which exhibited traces or remains of insects. In 1726[4] a book containing descriptions of fossil insects, was published by Beringer and Hueber; this was followed in 1729[5] by Bromell's "Lithographia Suecana;" in 1742[6] by the "Historia Succinorum," of Sendelius; and in 1779 by Schröter's "Lexicon."[7] Nothing more, worth noticing, then appeared on this subject for about 50 years, when in 1829,[8] M. Marcel de Serres produced an important work on the fossil invertebrates of the Tertiary formations of the South of France.[9]

xviii.e siècle, Scheuchzer et Sendelius eussent signalé des *Entomolithes;* et ce n'est qu'en 1839 que Brullé dans une thèse inaugurale, soutenue devant la Faculté des Sciences de Paris, fit presentir l'intérêt que pouvait offrir l'étude des Insectes fossiles."—See "Recherches sur les Insectes Fossiles des Terrains Tertiaires de la France" by E. Oustalet. "Annales des Sciences Géologiques," tome 2me. art No. 3, and the "Bibliothèque de l'école des hautes études," tome ive., article No. 7.

[1] "Sur le gisement des Insectes fossiles, et sur les secours que l'étude de ces animaux peut fournir à la Géologie." Thèse, 1839, in 4o.

[2] "Herbarium Diluvianum." Tiguri, 1700 & 1723 edit 2 in fol. Physica Sacra.

[3] "On sait que Linné a donné le nom d' *Entomolithes* aux pétrifications qui présentent des débris ou des vestiges d'insectes." Géognosie des terrains tertiaires, &c., (p. 207), by Marcel de Serres. 1829.

[4] Lithographiæ Wirceburgensis specimen primum. Fol. Wirceburg, 1726.

[5] Lithographia Suecana. Acta Litteraria Sueciæ II. 1729.

[6] Historia succinorum corpora aliena involventium. Lipsiœ, 1742.

[7] Lexicon, 1779. 8. T. 2. pp. 93-100.

[8] "Géognosie des terrains tertiaires, ou tableaux des principaux animaux invertébrés des terrains marins tertiaires du midi de la France." 16mo. Paris et Montpellier. 1829. See also, "Notes Géologiques sur la Provence." Actes: Linn: Soc: Bord: xiii. 1-82. 1843. See also "Notes sur les fossiles du bassin d'Aix." Ann: Sc: Nat. Vol iv., 1845.

[9] I am particularly indebted to Mr. W. S. Dallas, F.L.S., Assistant Secretary of the Geological Society, for allowing me to have access to the library of that Society, during a period of nearly 15 months, prior to the date of my election as a Fellow of the Society.

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In the same year (1829), a further contribution to our knowledge of fossil Entomology was made by the late[1] John Curtis, in a paper on the "Tertiary Formations of Aix," by Sir Roderick Murchison, and Sir Charles Lyell. The next work of any importance, which treated of this subject, was Bronn's "Lethæa Geognostica,"[2] published in 1835.

One of the most valuable works on this branch of Palæontology, and which has, perhaps, more than any other, directed the attention of Geologists to its interest and importance, is Professor Heer's "Die Insekten[3] fauna der Tertiärgebilde von Œningen und von Radoboj in Croatien." Professor Heer has done more to promote the study of this subject than any other Palæontologist, and has been justly styled, by Signor Massalongo,[4] "the Cuvier of fossil Entomology."

Amongst the names of English students of, and writers on the subject, the most prominent is that of the Rev. P. B. Brodie, M.A., F.G.S., who, in 1845, with the assistance of Professor Westwood, produced the *only book*[5] on Fossil Insects which has appeared in this country.

[1] See the "Edinburgh New Philosophical Journal" for October, 1829.

[2] "Lethæa Geognostica oder Abbildungen und Beschreibungen der für die Gebirgs-Formationen bezeichnendsten Versteinerungen." By Heinrich Georg Bronn. 1835, second edit. 1838.

[3] "Die Insekten fauna der Tertiärgebilde von Œningen und von Radoboj in Croatien." Leipzig, 1847-1853. See also, by the same author, "Zur Geschichte der Insekten." Verhandl. Schweiz. naturf. Gesellsch., xxxiv., 78-97. 1849. "Ueber die fossilen Insekten von Aix in der Provence." Vierteljahrsschr. naturf. Gesellsch. Zürich I., 1-40. 1856. "Ueber die Insekten fauna von Radoboj." Bericht 32e Versamml. Deutsch. Naturf. 118-121. 1858. "Untersüchungen über das Klima und die Vegetations Verhältnisse des Tertiärlandes." 4to. Winterthur. 1860; and translation of the same into French by Ch. Gaudin, 1861. "Die Urwelt der Schweiz," 1865; and translation of the same into English by Mr. W. S. Dallas, edited by Mr. J. Heywood.

[4] "Però fra tutti, quegli che portava al suo apogeo questa scienza fu il celebre Prof. Osvaldo Heer di Zurigo, il quale a buon dritto può vantarsi di essere il vero fondatore e riformatore di questa scienza, e deve essere salutato quale Cuvier della fossile Entomologia." Studii Palæontologici, p. 11. Verona, 1856.

[5] "A History of the Fossil Insects in the Secondary Rocks of England," by the Rev. P. B. Brodie, M.A., F.G.S. London, 1845. See also, by the same, a paper "On the Nature, Origin, and Geological History of Amber, with an account of the fossils it contains," in the report of the Warwickshire Natural History Society for 1871; also, by the same, a paper "On

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Several short memoirs and papers on the subject, have also been written by the Rev. F. W. Hope,[1] F.R.S., Professor Westwood,[2] F.L.S., Dr. Henry Woodward,[3] F.R.S., Mr. T. Vernon Wollaston,[4] F.L.S., Mr. Arthur Gardiner Butler,[5] F.L.S., and others.

In America, some attention has lately been devoted to Fossil Insects by Dr. Dawson,[6] Professor Dana,[7] Professor Denton, Professor Léo Lesquereux, Mr. Mead, Mr. Richardson, Dr. Horn, Mr.

the Distribution and Correlation of Fossil Insects in the Secondary Rocks." Warwick, 1874.

NOTE.—Various short *papers, memoirs,* and *notices* on the subject of fossil insects have from time to time appeared in the "Proceedings of the Geological Society," the "Quarterly Journal of the Geological Society," the "Geological Magazine," the "Transactions of the Entomological Society of London," the "Quarterly Journal of Science," and other periodicals; but with the exception of Brodie's "Fossil Insects" (which is now out of print) no *book* has been written on this subject in this country.

[1] See a paper on "Succinic Insects," by the Rev. F. W. Hope, F.R.S., in the "Transactions of the Entomological Society of London," 1, iii., 133-147; also another paper by the same on "The Fossil Insects of Aix, in Provence," in the "Transactions of the Ent. Soc. London," iv., p. 250-255; also another paper by the same, entitled "Descrizione di alcune specie d'insetti fossili," in the annals of the "Academia degli aspiranti naturalisti" (Achille Costa).

[2] See a paper entitled "Contributions to Fossil Entomology," by Professor Westwood, M.A., F.L.S., in the "Proceedings of the Geological Society of London," Vol. x., p. 378-396. 1854. Also, by the same, "Introductory Observations to Brodie's 'History of Fossil Insects in the Secondary Rocks of England.'" 1845.

[3] See a paper in the "Transactions of the Geological Society of Glasgow," vol. ii., pt. 3. p. 234-248, by Henry Woodward, F.R.S.; also a paper by the same on "The discovery of a new and very perfect Arachnide from the Ironstone of the Dudley Coal Field," in the "Geological Magazine" for September, 1871, vol. viii., p. 385; also a paper on "A new Arachnide, &c., in the "Geological Magazine," vol. ix., No. 9, September, 1872, and in the "Geological Magazine," vol. x., No. 3, March, 1873; also a paper on "An Orthopterous Insect from the Coal Measures of Scotland," in the "Quarterly Journal of the Geological Society" for February, 1876.

[4] See a paper on "The Brick Pit at Lexden, near Colchester," in the Quart. Journ. Geol. Soc., Vol. xix., 1863, pp. 393-400, by the Rev. O. Fisher, M.A., F.G.S., with "Notes on the Coleoptera," by T. Vernon Wollaston, M.A., F.L.S.

[5] See "Lepidoptera Exotica," pp. 126-128, by Arthur Gardiner Butler, F.L.S.; also a paper by the same in the Geol. Mag., x., No. 103. 2-4.

[6] See a paper by Dr Dawson, F.R.S., in the "Geological Magazine" for September, 1867.

[7] Sill. Journ. (2) Vol. xxxvii., p. 34.

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Meek, and by that distinguished Entomologist, Mr. Samuel H. Scudder,[1] to whose numerous writings, especially his exhaustive essay on "Fossil Butterflies," recently published in the "Memoirs of the American Association for the Advancement of Science," constant reference will be made throughout this paper.

Amongst other important contributors to our knowledge of fossil Entomology must be mentioned Burmeister,[2] Gravenhorst,[3] Charpentier,[4] Giebel,[5] Carl von Heyden,[6-13], Lucas von Heyden, [11-14]

[1] The Geological Magazine, Vol. v., April and May, 1868. "Memoirs of the American Association for the Advancement of Science." Salem, Mass., 1875. See also "Bulletin of the Geological and Geographical Survey of the Territories," Vol. ii., No. 1, and the Report of Progress, 1875-1876. Geological Survey of Canada. Proceedings of the Boston Society of Nat. Hist., vols. x., xi., and xviii. The American Naturalist, vols. i. and vi., &c.

[2] Handbüch der Entomologie. 1832-1855.

[3] "Bericht der Entomologischen Section." Ueber d. Arbeit u. Verhandl. Schlesisch. Gesellsch. 1834. 92-93.

[4] "Ueber einige fossile Insekten aus Radoboj in Croatien." Acta. Akad. Leop. Carol. xx., 401-410. 1843.

[5] Insekten reste in Wettiner Steinkohlengebirge. 1850.—"Deutschland's Petrefacten." 8vo. Leipzig. pp. 644. 1852.—"Fauna der Vorwelt," vol. ii. 8vo. Leipzig. 1856.—"Geologische Uebersicht der Vorweltlichen Insekten." Zeitschr. gesammt. Naturw. viii., pp. 174-188. 1856. —Zur fauna des Lithographischen Schiefers von Solenhofen, t. 9, p. 373-388. 1857.

[6] *Chrysobothris Veterana und Blabera avita* zwei fossile insekten von Solenhofen. "Palæontographica, vol. i., p. 99-101. 1851. (C. von Heyden).

[7] Reste von Insekten aus der Braunkohle von Salzhäusen und Westerburg. "Palæontographica," iv. pp. 198-201. 1854-1856. (C. von Heyden.)

[8] Fossile Insekten aus der Braunkohle von Sieblos. Dunker and Meyer's "Palæontographica," vol. v., pp. 115-126. 1858. (C. von Heyden.)

[9] Fossile Insekten aus der Rheinischen Braunkohle. "Palæontographica," vol. viii., 1-15. 1859-1861. (C. von Heyden.)

[10] Gleiderthiere aus der Braunkohle des Niederrheins, der Wetterau und der Rhön. "Palæontographica," vol. x., pp. 65-82, 1861-63. (C. von Heyden.)

[11] Bibioniden aus der Rheinischen Braunkohle von Rott. "Palæontographica," vol. xiv. 1865, 1866. (C. and L. von Heyden.)

[12] Käfer aus der Braunkohle des Siebengebirges. "Palæontographica," vol. xv., 1865-1868. (C. and L. von Heyden.)

[13] Fossile Insekten aus der Braunkohle von Salzhausen. "Palæontographica," vol. xiv. 1865-1866. (C. and L. von Heyden.)

[14] Fossile Dipteren aus der Braunkohle von Rott in Siebengeberge. "Palæontographica," Vol. xvii. 1867-1870. (L. von Heyden.)

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Saporta,[1] Ehrenberg,[2] Pictet,[3] Geinitz,[4] Unger,[5] Bérendt,[6] Germar,[7] Goldenberg,[8] Mayr,[9] Boisduval,[10] Hagen,[11] Von Münster,[12] Massa-

[1] "Etudes sur la végétation du Sud Est de la France a l'époque Tertiare," Ann. Sc. Nat. Bot. xv., 277-351. 1872.

[2] "Insectes dans l'ambre" (Froriep's "Notiz," 1841, t. xix.); and Leonh. & Bronn. n. Jahrb. 1843, p. 502.

[3] "Traité élémentaire de Paléontologie," vol. iv. Geneva, 1846. See also the Paris edition, 1854.

[4] Grundriss der Versteinerungskunde, pp. 179-190. 1845-1846.

Characteristik der Kreidegebirge, p. 13.

[5] "Fossile Insekten aus Radoboj," 1839, in the Nova. Acta of the Leop. Akad. Carol., and separately in 1842.

[6] "Die Insekten in Bernstein," 1st part. Dantzig, 1830. And "Die in Bernstein befindlichen organischen Reste der Vorwelt." 1845-1856.

[7] Insekten in Bernstein eingeschlossen, &c. "Magazin der Entomologie," 1813. T. 1, H. 1, pp. 11-18.

"Fauna Insectorum Europæ." Fasc xix. of the continuation of Panzer; or separately: Insectorum protogææ specimen sistens insecta carbonum fossilium. Hallé. 1837.

Ueber die Versteinerten Insekten des Juraschiefers von Solenhofen. Isis. iv., p. 421-424. 1837.

Die Versteinerten Insekten Solenhofens. Acta. Akad. Leop. Carol., t. 19, p. 1, pp. 187-222. 1839.

Die Versteinerungen des Steinkohlengebirges von Wettin und Lôbejün. Hallé, 1844-1853.

Beschreibung einiger neuen fossilen Insekten. Münster's Beiträge. (1841.) Heft 5.

1. In dem lithographischen Schiefer Baierns.

2. In Schieferthon des Steinkohlengebirges von Wettin.

Enige fossile Insekten aus der Braunkohle und dem Süsswassermergel von Aix. Zeitschrift der Deutschen Geol. Gesellchaft, t. 1, pp. 52-63. 1849.

[8] "Die fossilen Insekten der Kohlenformation von Saarbrücken." Sitzungsbericht der Kais. Akad. der Wissensch." Vienna, 1852; and in "Palæontographica" of Dunker and Meyer, Vol. iv. 1854-1856. "Neue Jahrb. für Mineralogie," &c. 1869 and 1870. And "Fauna Saræpontana Fossilis," pt. 1, 1873, and pt. 2, 1877.

[9] Die Ameisen d. Baltischen Bernstein. Königsberg, 1868.

[10] "Annales de la Société Entomologique de France," viii., Bull 11, 12; and ix., 371-374. 1839 and 1840.

[11] Entomologische Zeitung, 1846, p. 6.

Die fossilen Libellen Europas. Stett. Ent. Zeit., t. xi, p. 6-13. 1848.

Ueber die fossile odonate Stett. Ent. Zeit., t. x. 226-231. 1849.

Ueber die Neuroptern der Bernstein-fauna. Verhandl. Wein. Zool. Bot. Verein, Vol. iv, p. 221-232. 1854.

Die in Bernstein befindlichen Neuroptern, 1856. (Bérendt.)

Zwei Libellen aus der Braunkohle von Sieblos. Meyer's Palæontographica, Vol. v, p. 121-126. 1858.

P. Acutipennis aus der Braunkohle von Sieblos. Palæont., vol. viii. 1859.

"A Comparison of the Fossil Insects of England and Bavaria:" in the Entomologist's Annual, 1862.

Die fossile Odonaten Solenhofens Palæontographica, Vol. x. 1862.

Ueber die Neuroptern aus dem Lithographischen Schiefer in Bayern. Meyer's Palæontographica, Vol. x, p. 96-145. 1861-1863.

Neuroptern aus der Braunkohle von Rott in Siebengeberge. "Palæontographica," Vol. x, pp. 247-269. 1863.

Die Neuroptern des Lithographischen Schifers in Bayern. "Palæontographica.' 1866.

[12] "Beiträge zur Geognosie und Petrefacten Kunde." Bayreuth, 1841.

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longo,[1] Van Bénéden,[2] Dohrn,[3] Preudhomme de Borre,[4] ~~Adolphe~~ Charles[5] Brongniart, &c.

I now propose to refer briefly, in the descending order of geological succession, to the various British and Foreign formations of the Recent and Tertiary periods, in which remains of insects have been detected, and to enumerate, as far as possible, the several orders and species, to which such remains have severally been assigned.

Before doing so, it will be desirable to make a few observations on the probable circumstances, under which insects became embedded in certain strata, in which their remains have been discovered.

The estuarine and purely fresh-water formations are, as would naturally be expected, those in which the remains of insects have been found in the greatest quantities; but their remains have also been discovered, and in some cases in considerable numbers, in marine formations, such as the Stonesfield Slate of England and the Solenhofen Slate of Bavaria. Their presence in such formations, may be accounted for by supposing them to have been blown or washed out to sea from some neighbouring land, or to have been blown into the sea when attempting to cross it, and then sinking to the bottom, have become embedded in the sediments there accumulating.

It is well known to all Entomologists that insects migrate in vast armies, frequently crossing the sea to effect their purpose.

Pieris Rapæ has been known to cross the channel from France to England, in a dense swarm. On this subject an eye-witness has written—"Such was the density and extent of the cloud formed by the living mass that it completely obscured the sun from the people on board the steamer, for many hundreds of yards, while the insects strewed the deck in all directions." Mr. H. W. Bates,

1 "Studii Palæontologici. Verona, 1856.

2 Bulletins de l'Académie Royale de Belgique, 2me serie, Vol. xxiii.. pp. 384-400.

3 Zur Kenntniss der Insekten in der Primärformationem. "Palæontographica," Bd. xvi, pp. 129-136.

4 "Notes sur des Empreintes d'insectes fossiles," extracted from the "Annales de la Société Entomologique de Belgique," tome xviii. 1875.

5 Bulletins de la Société Géologique de France, tome iv, p. 459, 1876; and "Compte-Rendu de la Société Entomologique de Belgique." Série 2, No. 47. (1878).

NOTE.—No attempt is made here to give a *complete* list of the writings, on fossil Entomology, of the above-named authors. The bibliography of the subject will be dealt with at the end of the third paper.

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F.L.S., in his book on the "Amazons," mentions several instances of the flights of insects over the ocean. Live beetles have been caught at sea many miles from the shore. Swarms of locusts have been observed many hundreds of miles from land, and moths, dragon flies, and other insects have alighted on the decks of vessels in mid-ocean.[1]

The occasional presence of a fossil insect in marine formations may be thus accounted for; but where insect remains are detected in any abundance in such formations, the proximity of dry land, at the time of their deposition, may be generally assumed.

Wherever insects have been discovered in a fossil state, the *Coleoptera* are generally very numerous. This is easily accounted for by the hardness and indestructible nature of their *elytra*.

It is worthy of note that the insects even from the older strata (*e.g.*, the Coal Measures), are far more closely allied to existing species than the rest of the fauna of the ancient world; and although some of them cannot be identified with any living types, still there is, as Mr. Brodie observes, "a much less proportional difference in this respect than might fairly be expected; so that these fossils may be almost said to afford an exception to the usual conclusions which have been derived upon this subject."

It is evident, from a comparison of fossil insects with existing species, and from a study of their geographical distribution, that the temperature of Europe has, during the Tertiary Period, undergone considerable changes; and the distribution of genera, and the size of species, as well as the numerical proportion existing between various groups, indicate the former existence of a warmer climate in Europe than that now prevailing in the same latitudes.

Dr. Heer has noticed that the development of insects has been, as might be expected, influenced by that of the Vegetable Kingdom; certain species not having appeared prior to the period at which dicotyledonous plants attained their highest state of development.

It has been remarked by M. Oustalet,[2] that each formation, or rather each deposit (on the continent), in which fossil insects have been detected, is characterised by the prevalence of some particular

[1] See Wallace's "Geographical Distribution of Animals," Vol. i., p. 32. 1876.

[2] Recherches sur les Insectes fossiles, p. 26.

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family or order; thus the genus *Blatta* is especially well represented in the Lias of Aargau; the *Rhyncophora* in the marls of Aix; the *Buprestidæ* in the quarries of Œningen; the Ants in the sulphurous marls of Radoboj; and the *Termites* in the Baltic amber. This seems satisfactory evidence that each one of these groups found in its locality, during the period of its existence, all the essential requisites for its development.

I have a good deal to say on this subject, as well as on that of the dates of apparition of the various orders of insects on the Geological horizon; but my observations will be reserved until the end of the third paper of the series, when—having brought under review the various (insect) fossiliferous strata of the Recent, Tertiary, Secondary, and Primary Periods, and the orders, families, and species of insects which have been discovered therein—I shall be better able to draw general conclusions than I am in the introductory portion of the first paper.

I will now proceed to notice the various formations in which fossil insects have been detected, and the orders, families, and species to which such fossils have severally been referred.

In every case British strata and their fossils will be first alluded to, and then those of the Continents of Europe and America.

RECENT OR POST TERTIARY.

BRITISH STRATA.

One of the most recent deposits in this country, in which fossil insects have been detected, is that of the Brick earth at Lexden,[1] near Colchester. In a paper "on the Brick Pit at Lexden," in the "Geol. Society's Journal" for 1863, the Rev. O. Fisher states that he obtained a number of specimens of *Coleoptera* from this locality, which he submitted to Mr. T. Vernon Wollaston. Amongst these remains Mr. Wollaston identified several elytra of beetles, belonging to the following genera, viz.: *Cassida*, *Curculio*, *Coccinella*, *Chrysomela*, and *Cossyphus*. Some of these remains are referred, doubtfully, to *Carabidæ* and *Buprestidæ*. Mr. Wollaston states that, with one or two exceptions, these *Coleopterous* remains could not be referred to existing British species.

[1] On the Brick Pit at Lexden, near Colchester, Quart. Journ. Geol. Soc., Vol. xix. 1863, pp. 393-400, by the Rev. O. Fisher, M.A., F.G.S., with notes on the *Coleoptera*, by T. Vernon Wollaston, M.A., F.L.S.

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In the third volume of the Geological Society's Proceedings,[1] there is a paper, by Lyell, on "the Boulder formation, or drift, and associated freshwater deposits, comprising the mud cliffs of Eastern Norfolk." This paper contains an account of the discovery in the Mundsley deposit, of the elytra of certain Beetles, especially of the genus *Donacia*. Mr. Curtis was of opinion that in these remains there were two species of *Donacia*, both possibly identical with existing British Insects. The same Entomologist has also detected, in these fossils, the presence of an *Elater*, an elytron of one of the *Harpalidæ*, also another elytron, which he confidently referred to *Copris lunaris*.

Dr. Berger,[2] in his account of the Isle of Man, speaks of finding, in diluvial deposits, a vast number of the *exuviæ* of beetles, and bees and their nests, crushed together with seed vessels.

FOREIGN STRATA.

The most recent strata on the Continent of Europe, in which fossil insects have been found, are, according to Professor Heer,[3] the Lignites and Clays of Utznach and Dürnten, in Switzerland, which he refers to the Recent or Post Tertiary period.

M. Brullé records from these deposits a *Coleopterous* insect allied to *Feronia leucopthalma*, another similar to *Callidius fennicum*, and an *Elater* referable to *Elater* (*? Harpalus*) *æneus*. Professor Heer records from the same deposits two species of *Donacia*, resembling *Donacia discolor*, and *Donacia sericea*; and he says that their elytra lie by hundreds in some parts of the Lignite. Dr. Heer also describes a species of the genus *Hylobius* (*H. rugosus*), allied to *Hylobius pineti*, but distinct; an existing species of the genus *Pterostichus* (*P. niger*), and two extinct species of *Carabidæ*, viz., *C. diluvianus* and *C. cordicollis*.

In the 9th volume of the "Bulletins de la Société Géologique de France,"[4] M. Cordier is reported to have communicated to the Society an extract from a letter, addressed to him from Stockholm, by M. E. Robert, in which the latter stated that he had found, in the turf pits near Elsinore, remains of insects, including *Lucanidæ*, (*Cervus longirostris*), *Aphodius fossor*, two species of *Buprestidæ*, &c.

1 Geological Proceedings, Vol. iii., p. 175.
2 See Geol. Transactions, Vol. v., p. 501.
3 Urwelt der Schweiz, p. 481.
4 Bull. Soc. Geol. de France, t. ix., p. 114.

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TERTIARY OR CAINOZOIC.

The very small number of fossil insects, recorded from the Tertiary formations of the United Kingdom is remarkable, especially when compared with the great number of species described from European and American Tertiary formations.

No doubt the list of species in this country will be largely increased when further investigations have been made. The insignificance of the British list may, in a great measure, be accounted for by the fact that in this country, the researches and investigations of the Rev. P. B. Brodie, Professor Edward Forbes, Mr. W. R. Brodie, the Rev. O. Fisher, Captain Woodley, and others, have principally been in the Secondary Rocks—especially in the Middle and Lower Purbecks of the Upper Oolite, and in the Lias ; whereas, on the Continent of Europe, as much attention appears to have been bestowed on the formations of the Tertiary epoch, as on those of any other ; and besides, on the Continent, investigations have been carried on for a much longer period, and by a far greater number of persons.

BRITISH STRATA.

Lower Miocene.

In the list of fossil insects at the end of Mr. Brodie's paper on the "Distribution of Fossil Insects,"[1] I find recorded "Elytra of two species of beetles from the Miocene formation in the neighbourhood of Antrim, Ireland."

These beetles are also mentioned by Professor Judd, F.R.S., in his 1st paper on the "Volcanic Rocks of Scotland."[2]

[3]Mr. Pengelly, F.R.S., states[4] that when Professor Heer was in England, he devoted a few days to the deposits of Bovey Tracey, in Devonshire, and that amongst the remains from these strata he obtained one Beetle—*Buprestis Falconeri*. This insect, says Mr.

[1] See a paper on the "Distribution and Correlation of Fossil Insects, chiefly in the Secondary Rocks," by the Rev. P. B. Brodie, M.A., F.G.S., Warwick, 1874.

[2] Geol. Jourl., Aug., 1874, Vol. 30.

[3] See a paper on "The Lignites and Clays of Bovey Tracey, Devonshire," by W. Pengelly, in the Royal Society's Proceedings, Vol. xi, 1860-62.

[4] I am indebted to Professor John Morris, F.G.S., for calling my attention to this paper.

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Pengelly, was the first evidence of animal life which had been obtained from these strata.

Upper Eocene.

In the December number of "Nature" for 1874, Mr. E. J. A'Court Smith records the discovery, in the Eocene shale of Gurnet Bay, Isle of Wight, of "a bed of insects, flies and gnats, and the larvæ and pupæ of the latter, the larvæ in countless thousands; also the wings, in great number, of a variety of flies, butterflies, and grasshoppers; also a wing resembling that of a mole cricket; likewise two or three beetles."

In a letter to me on the subject, dated the 8th February last, Mr. A'Court Smith says—"I regret that I am unable to furnish you with more than the orders I have recognised in the insect collection obtained from the Eocene shale of this place. *Diptera* are well represented; *Hemiptera* by one or two species; *Lepidoptera* in considerable numbers, and several species; *Orthoptera* are mainly confined to beautiful wings of grasshoppers and crickets; there are also specimens of *Hymenoptera* and *Neuroptera*. There are fully one thousand specimens of insects, more or less perfect, quite a thousand wings from the most minute—scarcely to be recognised without a lens—to very fine specimens of grasshoppers, and other *Orthoptera*."

A sample of this collection—which is by far the most important yet obtained from English Tertiary strata—is at present in the possession of Dr. Henry Woodward, F.R.S., and by his courtesy I have had an opportunity of inspecting it.[1]

[1] Since this paper was read in June last, these insect remains have been identified by Dr. H. Woodward and Mr. Frederick Smith, and they have been described by Dr. Woodward in a paper read by him at a meeting of the Geological Society, on the 19th December last. In the abstract of the proceedings of the Society at this meeting, these fossils are thus described—"The remains of Insects noticed in this paper were obtained by Mr. E. J. A'Court Smith, from a thin bed of limestone, belonging to the Osborne or St. Helen's series at Thorness and Gurnet Bay, in the Isle of Wight. The collection is the result of about 20 years' work. The insect remains comprise about fifty specimens of *Diptera*, including wings of *Tipulidæ* and *Culicidæ*, and the pupa apparently of a gnat, one wing of a *Hemipterous* insect, and a flattened *Homopterous* insect, identified by Mr. F. Smith with *Triecphora sanguinolenta*; two specimens referred to the *Lepidopterous* genus *Lithosia*; only three *Orthoptera*, one a *Gryllotalpa*, the other two belonging to a grasshopper: thirty-five *Hymenopterous* wings, thirty-three of which are referred to ants of the genera *Myrmica*, *Formica*, and *Camponotus*; twenty-three examples of *Neuroptera* referred to *Termes*, *Perla*, *Libellula*, *Agrion*, *Phryganea*, and *Hemerobius*; and twelve of *Coleoptera*, including species of *Hydrophilus*, *Dytiscus*, *Anobium*, *Dorcus*, and *Staphylinus*."

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Middle Eocene.

In the Geological Society's Proceedings for 1854,[1] Prof. Westwood describes and figures certain *Buprestidæ* from the Leaf beds at Creech, near Corfe, Dorset, belonging to the Bagshot series of the Middle Eocene; also Elytra of *Helopidæ* and *Curculionidæ* from the same formation.[2]

Mr. Brodie informs me that Mr. J. S. Gardner,[3] F.G.S., has recently discovered remains of insects at Bournemouth, in the Leaf Beds of the Bagshot Sands; that they consist of *elytra* of *Coleoptera*, wings of gnats and bees, *Diptera*, &c.

Lower Eocene.

In the list at the end of Mr. Brodie's paper on the "Distribution of Fossil Insects," Elytra of *Coleoptera* are recorded from "the Lower Eocene of the Isle of Wight;" and Dr. Mantell,[4] in his "Geology of the Isle of Wight," mentions that "Mr. Webster has observed traces of *Coleopterous* insects in the London Clay, near Parkhurst."

In the "Geologist" for January, 1861,[5] Mr. Caleb Evans, states that he obtained a few insect remains from the Paludina bed at Peckham. These remains were referred to Dr. Henry Woodward and Mr. Frederick Smith. Dr. Woodward was of opinion that three of the specimens were not determinable; that one was the elytron of a species of *Curculionidæ*, genus *Strophosomus*, or *Cucorhinus* (?), and another an elytron of an *Elater*.

I can find no record of the discovery of any other fossil insects from British Tertiary[6] formations.

[1] Geol. Proc., Vol. x, p. 381. See also Quart. Journ. Geol. Soc., Vol. ix. p. 53-54, 1853.

[2] In a paper in the Annals and Magazine of Natural History for 1869, Mr. Wanklyn alludes to an insect discovered by him in the Bournemouth Leaf Beds, and also adds—"Remains of Insects from the Pipe Clay of Corfe have been figured in the Quarterly Journal of the Geological Society, in a paper by Mr. Prestwich."

[3] Since this paper was written Mr. J. S. Gardner has discovered further remains of insects in the Bournemouth Leaf Beds. Many of them are in a fair state of preservation, and Mr. Gardner has been good enough to lend them me for examination.

[4] "Geological Excursions Round the Isle of Wight," by Dr. G A. Mantell, F.R.S., p. 101; and the Quart. Jour. Geol. Soc., 1853, p. 53-54.

[5] "Geologist," January, 1861, p. 39-40,

[6] At page 254 of the "Geologist" for 1858, Mr. J. Brown, of Stanway records the occurrence of elytra of *Coleoptera* in a bed of peat at Stanway

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FOREIGN STRATA.

On the Continent of Europe, discoveries of insect remains in Tertiary Strata have been made chiefly at Œningen in Switzerland; Radoboj in Croatia; Corent and Menat in Auvergne; Siebengeberge on the Rhine; Aix in Provence; and at Monte Bolca in Upper Italy. The remains of many species have also been detected in Amber from various localities, but especially from the Amber which the Baltic Sea throws up on the coasts of Prussia. It is difficult to know exactly to what geological epoch this substance should be referred. Sir Henry de la Béche was of opinion that the Prussian deposits of Lignite and Amber belong to the Tertiary rocks, and that their place was probably above the supracretaceous group.

To whatever period, however, Amber may be most properly referable, I shall in this paper treat of it, and of the insect remains detected therein, after closing the subject of the Tertiary formations.

European Strata.

Upper Miocene.

The principal deposit of this period, in which insect remains have been detected, is the great lacustrine formation of Œningen, in the valley of the Rhine, between Constance and Schaffhausen.

The Œningen strata are said to consist of a series of marls[1] and limestones, many of them thinly laminated, and which appear to have slowly accumulated in a lake, probably fed by springs, holding carbonate of lime in solution. The organic remains have been chiefly derived from two quarries, the lower of which is about 550 feet above Lake Constance, and the upper quarry is about 150 feet higher.

From these quarries Professor Heer[2] had, by the year 1861, obtained 5,081 specimens of insects, viz.:—

	Specimens.		Specimens.
Coleoptera ...	2456	Hemiptera ...	598
Neuroptera ...	882	Orthoptera ...	131
Hymenoptera ...	699	Lepidoptera ...	5
Diptera	310		

1 See "Lyell's Elements of Geology," 6th edit., p. 248.

2 See "Die Insekten fauna der Tertiärgebilde von Œningen und von Radoboj in Croatien." "Urwelt der Schweiz," and "Recherches sur le Climat et la Végétation du pays Tertiaire," p. 197.

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This number of specimens comprised 844 species,[1] viz. :—

	Species.		Species.
Coleoptera ...	518	Hemiptera... ...	133
Neuroptera ...	27	Orthoptera ...	20
Hymenoptera ...	80	Lepidoptera ...	3
Diptera	63		

Professor Heer[2] observes, that by comparing the number of *specimens* of each order with the number of *species* of each order, we get the following average number of specimens to each species, viz. :—

Coleoptera=specimens	to	each	species	4·7
Neuroptera	„	„	„	33·
Hymenoptera	„	„	„	8·7
Diptera	„	„	„	5·
Hemiptera	„	„	„	4·6
Orthoptera	„	„	„	6·5
Lepidoptera	„	„	„	1·7

It will be noticed that the numbers of specimens and species of the *Coleoptera* greatly exceed those of any other order.

All the most important groups of the *Coleoptera*, as well as the majority of their families, are represented in the Œningen fossils.

	Species.		Species.
The Rhynchophora comprise	108	The Chrysomelina comprise	50
„ Sternoxi „ ...	67	„ Lamellicornia „ ...	42
„ Clavicornia „ ...	55	„ Longicornia „ ...	30
„ Geodephaga „ ...	54	„ Palpicornia „ ...	22

Each family, observes Dr. Heer, contains on an average about ten species, and each genus three species ; whilst at the present day, in Switzerland, each family includes about forty-five species, and each genus five. Europe, taken as a whole, contains at the present day about 7·9 species to each genus ; North America, 4·4, and South America, 6·7.

Of the 844 species above mentioned about 440 are referable to 45 genera peculiar to Œningen, viz. :—

	Genera.		Genera.
Coleoptera	21	Hemiptera	11
Hymenoptera	6	Orthoptera	1
Diptera	6		

[1] For list of species, see post,—pages 47-50.

[2] Recherches sur le Climat et la Végétation du pays Tertiaire, p. 197.

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In my introductory observations, I alluded to the conclusions which might be drawn, as to the climate and vegetation of a former epoch, from the study of its fossil insect fauna. I will now endeavour to explain, by reference to some of the Œningen fossils, the mode in which such conclusions may be arrived at.

M. Oustalet[1] and Professor Lacordaire remind us that insects in general, and the *Coleoptera* in particular, may be divided, according to the nature of their food, into two classes, viz., into *Carnivorous* species and *Herbivorous* species. The proportion which one of these classes bears to the other varies in different countries, and, according to Professor Lacordaire,[2] the number of *carnivorous* species, in proportion to the number of *herbivorous* species, rapidly diminishes as we approach the Equator.

M. Oustalet,[3] quoting Lacordaire, states that at the present day the proportion of *carnivorous* species of *Coleoptera* to the total number of species of that order, in the undermentioned countries, is as follows, viz. :—

IN THE NEW WORLD.

In North America	::	1	:	4·01[4]
„ South „	::	1	:	9·59
„ Rio Janeiro	::	1	:	22·51

IN THE OLD WORLD.[5]

In Siberia	::	1	:	2·90
„ Europe	::	1	:	3·87
„ Africa	::	1	:	5·55

Now, at Œningen, according to the discoveries of Dr. Heer, the fossil *carnivorous Coleoptera* are, to the total number of species of that order, in the proportion of 1 : 4·62, and to the *herbivorous* species of that order, in the proportion of 1 : 3·62; that is to say, the *carnivorous Coleoptera* were rarer in this locality, in Upper Miocene times, than they are in Europe at the present day; although they were much more numerous there than they are at the present

[1] Recherches sur les Insectes fossiles, p. 16.

[2] In his "Introduction á l'Entomologie," Vol. 2. p. 577, Lacordaire says, "La proportion relative des Coléoptères, créophages diminue rapidement à mèsure qu 'on se rapproche de l'Equateur."

[3] Recherches sur les Insectes fossiles, p. 16.

[4] In the "Recherches sur le Climat, et la Végétation du pays tertiaire," Dr. Heer gives this proportion as 1 : 4, and not 1 : 4·01, as given by M. Lacordaire.

[5] See "l'Introduction à l'Entomologie," Vol. 2, chap. xiv, p. 577, by Professor Lacordaire.

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day in tropical countries, especially South America. It may be inferred from the difference in the proportion existing between these two classes of the *Coleoptera*, in Miocene times, as compared with the proportion existing between them at the present day, and from the general character of the insect fauna of Œningen, that the climate of this part of Europe, during the Upper Miocene period, approached nearer to that of the tropics than at the present day; and this inference is materially strengthened by the study of the present geographical distribution of many of the genera and species of insects, inhabiting Œningen at that period.

The majority of the Œningen species belong to genera distributed at the present day, over the Old and New Worlds; and these genera are said to comprise more than two-thirds of the total number of species discovered in these strata. Dr. Heer estimates that out of 180 genera of this class, 114 belong to the *Coleoptera*. Of these 180 genera two are not found, at the present day, out of Africa (*Lepitrix* and *Gymnochila*)—two are specially American (*Anoplites* and *Naupactus*); but of the rest some are met with in Africa, Asia, and America, particularly in the last named country.

A great number of the species of this period are allied to existing American species, and very few of them belong to genera exclusively European[1]—17 genera still inhabit the old world; and eight of them, as well as the small number which are exclusively European, are still represented at the present day in the Mediterranean fauna.

On the subject of the insect fauna of this locality, Sir Charles Lyell[2] observes, "few of the genera of insects are extinct, but many of them imply a geographical distribution widely different from that now obtaining in the same part of the world."

Dr. Heer[3] found that the results furnished by an examination of the insect fauna of Œningen agreed, on the whole, with those arrived at from a study of the flora; though the character of the flora is more strictly American, and more tropical than that of the fauna.

[1] These genera (*i.e.*, those exclusively European) are *Amphotis*, *Prostemma*, *Eusarcoris*, *Heterogaster*, and *Pemphigus*. "Recherches sur le Climat," p. 203.

[2] See Lyell's "Elements of Geology," 6th edition, pp. 254-255.

[3] For a full account of Dr. Heer's deductions, see "Recherches sur le Climat et la Végétation du pays tertiaire," pp. 204-205.

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To this period (Upper Miocene) Dr. Heer refers certain strata at Parschlug, in Styria, Austria; from which he enumerates 14 species of insects, viz.[1]:—

	Species.		Species.
Coleoptera	7	Hymenoptera	2
Orthoptera	2	Diptera	2
Neuroptera	1		

The classical deposits of Senigallia, in the north-east of Italy, also belong to the Upper Miocene period.

These deposits, so famous for the quantity of animal and vegetable remains detected therein, contain, says Signor Massalongo,[2] numerous impressions of insects. [3]Many beautiful specimens of insects are said to have been obtained from these beds by the Rev. F. W. Hope, but I am not aware that he ever published any description of them.

It was from these strata that Signor Procaccini-Ricci[4] obtained a considerable number of species, which afterwards formed part of the collection of Signor [5]Giuseppe Scarabelli di Imola.

Signor Massalongo[6] describes two fossil larvæ of the genus *Libellula*, which he states that he found in splitting open some slabs of stone from this locality. He has named one species *Libellula Eurynome*, and the other species *Libellula Doris*. With this exception, I have failed to meet with the description of any Fossil Insects from Italian strata of this period.

Middle Miocene.

To this period are referred the Marls of Radoboj, in Croatia, which have been productive of a great quantity of insect remains.

[1] See "Recherches sur le Climat et la Végétation du pays tertiaire," p. 197.

[2] "Le classiche gessaje del Sinigalliese rese celebri, per le copiose reliquie di esseri organizzati appartenenti tanto al regno animale che vegetale, racchiudono anche non rade impronte di insetti." "Studii Palæontologici," Verona, 1856, p. 22.

[3] Mr Brodie informs me that the insects collected by Mr Hope from Senigallia, are in the Taylor Gallery, at Oxford.

[4] I have not been able to find any description of these fossils in the only work of Signor Procaccini-Ricci's to which I have had access.

[5] In op. cit. Massalongo says, "Voglio sperare che il mio amico Giuseppe Scarabelli che si è arricchito della raccolta del defunto Procaccini-Ricci, vorrà quanto prima fare di pubblica ragione la bella serie di insetti petrificati di questo luogo, dei quale è possessore."

[6] "Studii Paleontologici," pp. 22 and 23, plate 1, figs. 8-13.

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[1]Professor Unger was the first author who published, (in 1839) on the fossil insects of this locality, a memoir of any importance. This was followed, in 1843, by a paper by [2]Von Charpentier (in the Acta. Akad. Leop. Carrol.). Since then[3] Professor Heer has thoroughly studied the fossil insect fauna of Radoboj, in which he has recognised a great number of tropical forms, including some gigantic *Termites*.

Of the insects from this locality, 312 species have been determined, viz. :—

	Species.		Species.
Coleoptera about ...	42	Lepidoptera about ...	8
Orthoptera „ ...	13	Diptera „ ...	83
Neuroptera „ ...	20	Hemiptera „ ...	61
Hymenoptera „ ...	85		

The *Coleoptera* are comparatively rare, and most of the species are only represented by individual specimens ; but the [4]ants are represented by 57 species, of one of which (*Formica occultata*), Dr. Heer is said to have obtained 594[5] examples. [6]Sir Charles Lyell observes of this locality—"The insect fauna is very rich, and, like the plants, indicates a more tropical climate than do the fossils of Œningen. There are 10 species of *Termites*, some of gigantic size, and large dragon flies with speckled wings like those of the Southern States of North America; there are also grasshoppers of considerable size, and even the *Lepidoptera* are not unrepresented."

The first species (*E. atava*) of this order, *i.e.*, *Lepidoptera*, was first described by Von [7]Charpentier, and referred by him to the genus

[1] "Fossile Insekten aus Radoboj." Verhandl. der Kais. Leop. Akad. der Naturforscher, t. 19, pp. 412-428.

[2] Uber einige Fossile Insekten aus Radoboj in Croatien, "Acta Akad. Leop. Carol.," vol. 20, p. 401-410. 1843.

Von Charpentier describes 7 species, including one *Lepidopterous* Insect, which he referred to the genus *Sphinx*, but which has subsequently been identified as a butterfly, *i.e.*, *Eugonia Atava*.

[3] Die Insekten fauna der Tertiärgebilde, &c.; also "Ueber die Insekten fauna von Radoboj." Bericht 32e. Versamml, Deutsch. Naturf. 118-121. 1858.

[4] See "Recherches sur le Climat et la Végétation du pays Tertiaire," p. 197.

[5] So says M. Oustalet, but Dr. Heer, in his "Recherches sur le Climat," says 500.

[6] Lyell's "Elements of Geol.," p. 243. See also "Recherches sur le Climat," p. 205.

[7] "Acta Akad. Leop. Carol," xx., 408.

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Sphinx. Dr. Heer[1] refers it to the genus *Vanessa;* but Mr.[2]Scudder places it in the genus *Eugonia*, "the position," he says, "dubiously assigned to it by Kirby, in his 'Synonymic Catalogue.'" The genus to which Mr. Scudder refers this fossil is represented equally in Europe and America.

The second species, [3]*Mylothrites Pluto*, is described by Heer, and referred by him to the genus [4]*Vanessa*. It is also described and figured by Sir Charles Lyell, who observes—"In one instance, the pattern of a butterfly's wing has escaped obliteration in the marlstone of Radoboj; and when we reflect on the remoteness of the time from which it has been faithfully transmitted to us, this fact may inspire the reader with some confidence as to the reliable nature of the characters which other insects, of a more durable texture, such as the beetles, may afford for specific determination." Mr. W. H. Edwards,[5] of Western Virginia, in his work on American butterflies, expresses an opinion that this species ought to have been referred to the genus *Argynnis*. I have carefully examined the species of this genus, which Mr. Edwards considers the nearest living representative of the fossil species *Pluto*, in the collection of the British Museum; but I fail to trace in it any but a very superficial resemblance to the latter, of which it is nearly double the size. My friend Mr. Butler[6] refers it to the genus *Junonia*, but Mr. [7]Scudder states that the new drawing of the fossil, which he received through his friend Herr Brunner von Wattenwyl, leaves little doubt that the insect is a *Pierid*, and belongs to some genus intermediate between *Mylothris* and *Hebomoia;* and he describes and figures the insect as *Mylothrites Pluto*. The remains of this insect are particularly interesting, as belonging to an extinct genus whose nearest living representatives, according to Scudder,[8] "are to be looked for in the genera *Mylothris* and *Hebomoia*, the former of which finds its highest development in torrid Africa, while the latter is confined to the Indo-Malayan Austro-Malayan regions."

[1] "Die Insekten fauna," &c., 2, pp. 177-79.
[2] Scudder's "Fossil Butterflies," pp. 41-44.
[3] "Die Insekten fauna," &c., 2, pp. 179-82.
[4] "Recherches sur le Climat," &c., p. 205, Dr. Heer says, "corresponds with *Vanessa Hadena* of India." See also Lyell's "Elements of Geology," 6th edit., p. 243.
[5] "Butterflies of North America," by W. H. Edwards.
[6] "Lepidoptera Exotica," pp. 127, 128, by Arthur Gardiner Butler.
[7] Scudder's "Fossil Butterflies," 45-51.
[8] Op. cit., p. 78.

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[1]The remains of the third and last species from Radoboj, *Pontia Freyeri*, are also described by Heer and Scudder. The genus is a modern one, which is well represented by existing species, especially in the old world.

Lower Miocene.

From the lower Molasse[2] of Switzerland, Professor Heer enumerates 33 species of insects, viz. :—

	Species.		Species.
Coleoptera	26	Diptera	1
Neuroptera	2	Hemiptera	3
Hymenoptera	1		

The [3]lignites called Brown Coal, in Germany, belong for the most part to this period (Lower Miocene), and are often rich in insect remains.

The lignites of Rott, in Siebengeberge, near Bonn, are the best known. From these lignites about 29 species of insects had been recorded by the year 1856, according to Bronn,[4] Germar,[5] and Giebel.[6] These 29 species[7] were distributed amongst the undermentioned orders as follows, viz. :—

	Species.		Species.
Coleoptera	18	Diptera	5
Hymenoptera	2	Orthoptera	1
Lepidoptera	1	Hemiptera	2

In 1859,[8] Carl Von Heyden describes 21 additional species from this locality, viz. :—

	Species.		Species.
Coleoptera	12	Lepidoptera	1
Hemiptera	1	Diptera	5
Hymenoptera	2		

[1] "Die Insekten Fauna," &c., 11, 182-183; and Scudder's "Fossil Butterflies," pp. 54-56 and 78.

[2] See "Recherches sur le Climat et la Végétation du Pays Tertiaire," pp. 196-197.

[3] Lyell's "Elements of Geology," 6th edit., p. 244.

[4] "Lethea Geognostica," Vol. ii., p. 811.

[5] "Insectorum Protogeæ Specimen, &c.," in the "Fauna Insectorum Europæ," and "Zeitschrift der Deutschen Geol. Gesellschaft," 1, p. 52.

[6] "Zeitschrift fur die Gesammte Naturwissenschaft," viii., 1856, s. 184; and in "Fauna der Vorwelt." 8vo. Leipzig, 1856.

See also "Recherches sur les Insectes Fossiles," &c., E. Oustalet; and "Traité élémentaire de Paléontologie," by F. J. Pictet, Vol. iv., pp. 92-113.

[7] For a list of species, see post,—pages 52-53.

[8] "Fossile Insekten aus der Rheinischen Braunkohle," Dunker and Meyer's "Palæontographica," Vol. viii., 1-15.

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The subsequent investigations of Professor Heer,[1] Dr. Hagen,[2] and Herren Carl von Heyden and Lucas von Heyden,[3] raised the number of species from Siebengeberge to 180, viz. :—

[1 3] Coleoptera	92	species	([1] 32 in Heer's list). ([3] 60 described by Carl and Lucas von Heyden)
[1] Orthoptera	1	„	(in Heer's list).
[2] Neuroptera	12	„	([2] 10 described by Hagen). (2 in Heer's list).
[1] Hymenoptera	3	„	(Heer's list).
[1] Lepidoptera	2	„	„ „
[1] Hemiptera	5	„	„ „
[1] Diptera	65	„	([1] 12 in Heer's list). ([4] 23 described by C. and L. von Heyden). ([5] 30 described by L. von Heyden).

It will be noticed that only two Lepidopterous insects are enumerated from this locality. One of them is a butterfly, described by Carl Von Heyden as *Vanessa Vetula*.[6] Of this fossil Mr. Scudder[7] observes, "The single fossil represented by Von Heyden, under the name of *Vanessa vetula*, is preserved on a greasy, dark brown, thin and exceedingly fragile sheet of 'brown coal,' and is likely to become so affected by weathering as to be quite undistinguishable in the course of time." Mr. Scudder further observes that *Vanessa vetula* is the only butterfly yet found from the horizon of the aquitanian or Lower Miocene, and that it is closely related to *Thanaos*, a genus belonging to the North temperate zones of both hemispheres. The genera adjacent to *Thanaos* are said to be purely American, although tropical or subtropical, and therefore this species "looks towards subtropical North America for its relatives of the present day."

In the 10th vol.[8] of Meyer and Dunker's Palæontographica

[1] "Recherches sur le Climat et la Végétation du pays Tertiaire.' p. 197.
[2] "Neuroptern aus der Braunkohle von Rott in Siebengeberge." "Palæontographica," Vol. x, 1861-1863, pp. 247-269 (10 out of the 12 species are here described by Dr. Hagen.)
[3] "Käfer aus der Braunkohle des Siebengeberges," Meyer and Dunker's "Palæontographica," Vol. xv., 1866.
[4] "Bibioniden aus der Rheinischen Braunkohle von Rott," "Palæontographica," Vol. xiv., 1865.
[5] "Fossile Dipteren aus der Braunkohle von Rott in Siebengeberge." "Palæontographica," Vol. xvii., p. 237-272 (1867-1870).
[6] "Fossile Insekten aus der Rheinischen Braunkohle." "Palæontographica," Vol. viii., 12-13. Taf. 1, fig. 10. 1859.
[7] Fossil Butterflies, p. 63, plate 3, figs. 12-16.
[8] Palæontographica, Vol. x (1862) S. 62-82.

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(1862) 31 further species of insects are described from the liguites or brown coal of the Nether-Rhine and the Rhone, viz. :—

	Species.		Species.
Coleoptera	20	Neuroptera	1
Orthoptera	1	Lepidoptera	1
Hymenoptera	3	Diptera	5

Amongst other deposits of brown coal, in which fossil insects have been detected, may be mentioned those of Von Sieblos, Stöschen, and Salzhausen, from which Dr. Hagen,[1] Carl von Heyden,[2] and Lucas von Heyden, describe about 34 species, including some gigantic *Neuroptera*.[3]

The total number of species from the lignites or brown coal of the Rhine and the Rhone, which had been determined by the year 1863, amounted, according to Dr. Hagen,[4] to 103. Since that date 142 further species have been obtained from the same deposits, giving us up to the year 1870, a total of 245 species distributed among the undermentioned orders, as follows:—

Coleoptera	126 species	(69 described by C. & L. Von Heyden, *i.e.* 60 from Siebengeberge & 9 from Salzhausen.)
Orthoptera	6 „	
Neuroptera	16 „	(14 described by Dr. Hagen).
Hymenoptera	8 „	
Lepidoptera	3 „	(one of these is Vanessa Vetula).
Hemiptera	10 „	
Diptera	76 „	(25[5] described by C. & L. Von Heyden).
		(30[6] „ „ L. von Heyden).
	245	

During the last seven years, numerous additions *may* have been

[1] See Hagen's papers on "Zwei *libellen* aus der Braunkohle von Sieblos,' and on "*Ascalaphus proavus* aus der Rheinischen Braunkohle," in "Palæontographica," Vol. v., taf. xxiv; and on "*Petalura Acutipennis*," in "Palæontographica," Vol. viii.

[2] See Von Heyden's papers on "Fossile Insekten aus der Braunkohle von Sieblos," in "Palæontographica," Vol. v.; and on "Fossile Insekten aus der Rheinischen Braunkohle," Vol. viii.

[3] *Heterophlebia jucunda, Lestes vicina, Ascalaphus proavus, &c.*

[4] See "Neuroptern aus der Braunkohle," &c., in Palæontographica, vol. 10, 247-269 In this memoir, Dr. Hagen says, "Es sind also aus der Braunkohle des Niederrhein's, der Wetterau, und der Rhön 57 Coleoptera, 6 Orthoptera, 2 Neuroptera, 8 Hymenoptera, 3 Lepidoptera, 7 Hemiptera, 20 Diptera im ganzen 103 arten bekannt."

[5] Carl Von Heyden and Lucas Von Heyden in vol. xiv. of "Palæontographica" (1865-1866) describe 12 species of insects (including two *Diptera*) from Salzhausen.

[6] Lucas Von Heyden describes 30 further species of Diptera from the brown coal of Rott in "Palæontographica," Vol. xvii., 1867-1870, pp. 237-272.

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made to this list; but if they have, I have been unable to find any record of them.

To this period (Lower Miocene) are referred the freshwater formations of Auvergne, in Central France. These formations are, in some places,[1] partly composed of that remarkable form of limestone called "indusial," from the cases or *indusiæ* of the Caddis worms, or larvæ of *Phryganea*, great heaps of which have been encrusted as they lay, by carbonate of lime, and formed into a hard travertin. These Caddis worms are abundant at the bottom of freshwater streams and lakes, and many of the freshwater limestones of this locality are, according to Dr. Mantell,[2] almost wholly composed of these cases cemented together by calcareo silicious matter into stone, which is much employed for building purposes. "If we consider," says Mr. Scrope,[3] "that repeated strata of five or six feet in thickness, almost entirely composed of these tubes (cases), once extended over a district presenting a surface of many hundred square miles, we may have some idea of the countless myriads of minute beings which lived and died within the bosom of that ancient lake."

Professor Pictet seems to entertain some doubt as to whether the tubes or cases, before mentioned, of which the indusial limestone is in a great measure composed, were formed by larvæ of *Phryganea* or Caddis worms. He says these tubes are much thicker than those formed by *Phryganea;* the internal cavity is much smaller; and they are,[4] besides, much longer, and more resemble the tubes formed by certain *Annelida*.

M. Oustalet has recently made a special study of the fossil insect fauna of Auvergne, and has published on the subject a most important memoir,[5] (a copy of which he has presented to me) only

[1] See Lyell's "Elements of Geology," 6th edit., pp. 223-225.
[2] "The Medals of Creation," vol. ii., pp. 557-9.
[3] "The Geology of Central France," by G. Poulett Scrope, 1827.
[4] "Quelques auteurs attribuent a des larves de *Phryganes* des tubes que l'on trouve dans certains terrains d'eau douce du midi de la France. Ces tubes formés de grains de sables, ou de petits coquilles agglutinées, ne me paraissent en aucune maniére pouvoir être considérées comme faits par des larves de ce genre. Ils sont beaucoup plus épais que tous ceux que forment les *Phryganes* actuelles; la cavité interne est beaucoup plus petite; ils sont d'ailleurs plus longs, &c. Ils ressemblent plus aux tubes que se font certaines Annélides." "Traité élémentaire de Paléontologie," vol. iv., p. 108.
[5] Recherches sur les Insectes fossiles des Terrains Tertiaires de la France ("Bibliothêque de l'école des hautes études," and in the "Annales des Sciences Géologiques") Paris, 1871.

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equalled, in my opinion, in importance by Professor Heer's great work on the Insect fauna of Œningen and Radoboj.

The localities in this part of France, in which the majority of these fossils have been discovered, are Corent, Menat, and St. Gerand le Puy. From these localities, M. Oustalet states, that he has studied not less than 100 specimens in the collections of M.M. Lecoq and Fouilhoux, and in that of the Museum of Natural History at Paris, or collected by himself during his travels in Auvergne. These specimens comprise some 49[1] species, distributed amongst the undermentioned orders in the following manner, viz. :—

	Species.		Species.
Coleoptera	10	Hymenoptera	2
Orthoptera	1	Diptera	30
Neuroptera	5	Lepidoptera	1

The entire absence of any *Hemiptera* from this list is as remarkable as the extraordinary number of the *Diptera*.

M. Oustalet [2] observes that this last feature strikes us equally in the fauna of Radoboj, in that of Aix in Provence, and especially in that of the lignites of the Rhine, where the two genera *Bibio* and *Protomyia* constitute a large majority. The Ants, which are represented at Radoboj by 57 species (of one of which alone 500 specimens have been discovered), are entirely absent from Corent. The larvæ of the genus *Libellula* are also very rare there, whilst they form entire slabs [3] in the Œningen deposits. Next to the *Diptera* the *Coleoptera* are the best represented.

The fossil fauna of Auvergne, which have been studied by M.M. Pomel Aymard, Alphonse Milne-Edwards, and others, comprises both European and South American forms. The Reptiles, in particular, are said to have a more decided affinity, than animals of the other classes, with South American species of the present day. The insects, remarks M. Oustalet, form no exception to this rule, and include, like the other classes of the fossil fauna of Auvergne, both indigenous and exotic types; although, perhaps, the majority of the species are referable to existing European genera, there are many others whose nearest living allies are now

[1] 44 of these species are from Corent, three from Menat, and two from St. Gerand le Puy.

[2] "Recherches sur les Insectes fossiles," pp. 160-161.

[3] "Recherches sur le Climat et la Végétation du pays tertiaire," p. 97.

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comprised in the fauna of Brazil. M. Oustalet further remarks that at Corent, as at Aix and Œningen, the Entomological fauna is in character partly American and partly Mediterranean; and that it may be fairly assumed that the land and freshwater conditions of Auvergne, during the Miocene period, were similar to those of Brazil at the present day; and that this part of France enjoyed, at the commencement of the Miocene or Middle Tertiary period, a climate only slightly colder than that now prevailing in Brazil.

The most recent discovery of fossil insects in this part of France has been made by[1] M. Ch. Brongniart, who, in the "Bulletin de la Société Géologique de France" for the year 1876, described a new species of a *Dipterous* insect, which he has referred to the genus *Protomyia*, and named *P. Oustaleti*, in recognition of the very important contributions to our knowledge of the fossil insect fauna of France, made by M. Oustalet. The genus *Protomyia* of Heer, observes M. Brongniart, contains no living representatives, although it was numerously represented during the Tertiary period, nearly 40 species referable to it having been described by Dr. Heer, C. and L. Von Heyden, and M. Oustalet.

According to M. Brongniart, this new species was discovered in the calcareous marl of the inferior Miocene formation of Chadrat, in Auvergne: and it differs from all previously described species in the distribution of the nervures, and appears most closely allied to *P. Joannis* and *P. Bucklandi*.

Upper Eocene.

Nowhere in the continental formations of this period, with the exception of Œningen, have fossil insects been discovered in greater abundance than at Aix, in Provence.

The town of Aix, according to[2] Dr. Mantell, is situated in the lowest part of a deep valley, the immediate flanks of which are composed of a thick freshwater formation, lying unconformably upon strata of Jura limestone. The freshwater series consist of white and grey calcareous marls, calcareo-siliceous grits, and beds of gypsum.

[1] "Bulletins de la Société Géologique de France," tome 4me. p. 459, (1876).

[2] See "The Medals of Creation," Vol. ii., p. 557; also a paper on "The Tertiary Freshwater Formations of Aix, in Provence," by Murchison and Lyell, in the "Edinburgh New Philosophical Journal" for October, 1829.

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M. Marcel de Serres[1] was the first to make known to the scientific world the occurrence of insects in these gypseous marls.

In his [2]" Géognosie des terrains tertiaires" he enumerates about 80 genera from this locality, comprising the following, viz.:—

	Genera.		Genera.
Coleoptera	20	Hymenoptera... ...	9
Orthoptera	6	[3] Lepidoptera	4
Hemiptera	14	Diptera	20
Neuroptera	2		

The insects included in these genera were said by Marcel de Serres to be all of European forms, and [4]to be mostly referable to species still existing.

A number of insects from this locality (including some 45 species) collected by Murchison and Lyell,[5] were described by Mr. Curtis in 1829. They consisted principally of *Diptera*, *Hemiptera*, and *Coleoptera*, with a few *Hymenoptera*, and one *Lepidopterous* insect. According to Curtis, several of the beetles had their wings extended beyond the *elytra*, as if they had been flying, and had dropped; and a *Chrysomela* had the *elytra* expanded, from which it would appear that it had fallen upon the water and been drowned. Other insects appear to have been imbedded whilst in repose, or when walking.

Some eight years later, when [6]Bronn published his "Lethæa Geognostica," a great number of other insects appear to have

[1] See "Bulletin des Sciences," Vol. viii., p. 181 (No. 15), also "Géognosie des terrains tertiaires," &c., pp. 220-2.

[2] See "Traité élémentaire de Paléontologie," by F. J. Pictet, Vol. iv., pp. 100-14.

[3] "*Papilio* de la division, '*Satyrus*.' *Zygæna*: une éspèce peut-être de ce genre, mais faute de caractères positifs il est bien incertain que notre insecte s'y rapporte. *Sesia*; une espèce voisine de la *Sesia vespiformis*. Une autre espèce moins allongée a corps, plus gros et à peu près de la stature de la *Sesia brosiformis* d'Hubner. *Bombyx*; un *Lepidoptere* nocturne du genre *Bombyx* ou *Cossus*." Géognosie des terrains tertiaires, &c., p. 230. Marcel de Serres.

[4] "Il est donc certain que les débris d'insectes fossiles du bassin d'Aix se rapportent uniquement à des espèces Européennes et même la plupart, a ce qu'il parait, à des espéces qui vivent encore dans nos contrées méridionales." *Op. cit.*, p. 233

[5] See the "Edinburgh new Philosophical Journal" for October, 1829, pp. 287-297; also the "Quarterly Journal of Science" for September, 1828; also the "Geological Proceedings," Vol. 1, p. 151, and Vol. iii., p, 505.

[6] See "Lethæa Geognostica,," Vol. ii., p. 811.

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been discovered in this locality, for in the second vol. of the last-named work the following are enumerated:—

	Genera.		Genera.
Of the Coleoptera ...	33	Neuroptera	2
Orthoptera	6	Hemiptera	17
Hymenoptera	9	Diptera	22

besides the four *Lepidoptera* mentioned by Marcel de Serres.

By the year 1844 the researches and investigations of the Rev. F. W. Hope, F.R.S.,[1] in this locality, had raised the number of genera enumerated by Marcel de Serres, Curtis and Bronn, to 113, for some 20 of which we are indebted to Mr. Hope.

For some years after the date of Mr. Hope's paper, the fossil insects of Provence, which had for a time attracted a considerable amount of attention from Geologists and Palæontologists, remained unnoticed, until, in 1851,[2] Professor Heer commenced to study them. In addition to the specimens he himself obtained during a tour in Provence, he was enabled to study those in the collection of M. Blanchet, of Lausanne, and those collected by Sir Roderick Murchison in 1829. M. Oustalet observes that, from a study of these fossils, and a comparison of their species with those found in the strata of Œningen and Radoboj, combined with the study of the fossil flora of these strata and those of the Swiss and German localities, Professor Heer was enabled to arrive at most interesting conclusions on the climate and conditions of life prevailing at that era of the Tertiary period in various countries of central Europe.

Of the 60 fossil species from the marls of Aix, contained in the collections above mentioned, Dr. Heer states that nine have been found at Radoboj, and four at Œningen; that is to say that at Radoboj twice as many species are found in common with Aix as at Œningen, although this last locality is much nearer Provence, and possesses a much richer fauna, and consequently offers many

[1] See a paper entitled "Observations on the Fossil Insects of Aix, in Provence," by the Rev. F. W. Hope, F.R.S., in the iv. Vol. of the "Transactions of the Entomological Society of London," pp. 250 255. Also, by the same, "Descrizione di alcune specie d'insetti fossili," in the Annals of the "Academia degli aspiranti Naturalisti," December, 1847.

NOTE.—This memoir appears to have been written by Mr. Hope in French, and to have been translated into Italian by Signor Achille Costa, who added to it some observations in parenthesis.

[2] "Ueber die fossilen Insekten von Aix in der Provence," Vierteljahrsschr naturf. Gesellsch, Zürich I., 1-40. 1856.

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more points of comparison. Even those species which are not common to both Radoboj and Aix, but are confined to the last locality, are most intimately connected with those of the former. M. Oustalet remarks that at the time at which Dr. Heer was writing, the exact geological position of the gypseous marls of Aix had not been determined, but that they were regarded as contemporaneous with those of Montmartre, belonging to the Ligurian or Upper Eocene. From his study of their fossil insects Dr. Heer was of opinion that the geological position of these marls should have been somewhat higher up—nearer the marls of Radoboj in the Miocene formation.

Dr. Heer's conclusions, derived almost solely from an investigation of the fossil insects of the district, have, says M. Oustalet, since been to a great extent confirmed by the majority of Geologists, who have subsequently studied this formation; and although the strata have not been referred to the same period as the marls of Radoboj, they have been placed nearer to them, at the base of the Miocene period, almost on a level with the sandstone grit of Fontainbleau.

M. Marcel de Serres[1] stated, as I have before observed, that the majority of the fossil insects of Aix belonged to existing European forms, and he concluded from this that the geological conditions of Aix during the Upper Eocence period were similar to those of the present day.

The conclusions of Marcel de Serres, observes M. Oustalet,[2] are far from being, in all respects, confirmed by recent observations; for whilst admitting that the fossil fauna of Provence contains a number of types, if not identical with, at least closely allied to those now inhabiting the Mediterranean basin, it also contains several forms which, at the present day, are only represented in the south of Africa, in Asia, and America.

According to Count Saporta,[3] the fossil flora of the Aix district has a more southerly character than even the fauna; and it may be safely inferred from its fossil fauna and flora that the climate of Aix, at the end of the Eocene and commencement of the Miocene period, more nearly approached that of the tropics than at the present day.

One of the most remarkable facts connected with the Aix

[1] "Géognosie des Terrains Tertiaires," &c.
[2] "Recherches sur les Insectes fossiles,' &c., pt. 2, p. 6.
[3] "Etudes sur la Végétation du sud-est de la France à l'epoque Tertiaire," 1872.

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formations, and which has perhaps served to render them more interesting to Entomologists than any others from which fossil insects have been obtained, is that of the *nine* well authenticated fossil butterflies from the Tertiary formations, *five*[1] of them have been found here. Of these five species, the first discovered, and the best known is *Neorinopis sepulta*,[2] the earliest notice of which is given by Marcel de Serres in the "Annales des Sciences Naturelles" for 1828. Mr. Scudder, who has figured and described the insect,[3] states that the earliest definite mention of it is given by Duponchel, in the [4]"Bulletin de la Société Entomologique de France," in the following words:—"M. Duponchel entretient ensuite la Société d'un fait extraordinaire, et peut être entierement nouveau dans les annales de la Science. C'est l'existence d'une impression très remarquable de Lépidoptère fossile, qui a été trouvée dans une plâtrière des environs d'Aix, et acquise par M. de Saporta." This fossil was subsequently described and figured by Dr. Boisduval.[5] Mr. Butler has referred the species to the *Satyridæ*, and has described and figured it in his "Lepidoptera Exotica."[6]

The second fossil butterfly from these formations is described, for the first time, by Mr. Scudder as *Lethites Reynesii*.[7] It does not, in his opinion, belong to any existing European genus, and he mentions *Maniola Hermione* as its nearest ally among living European species. This fossil was detected by Mr. Scudder in the Museum at Marseilles, and named by him, after Dr. Reynès, the Director of that establishment. It appears to have been previously overlooked.

The third butterfly from Aix[8] is in the collection of Count Saporta,[9] and has been described and figured by Scudder, and named by him

[1] See Scudder's "Fossil Butterflies," p. 83.

[2] See the last mentioned work, p. 14; also "Les Annales des Sciences Naturelles" for 1828, and the "Géognosie des Terrains Tertiaires." See also "Ueber die fossilen insekten von Aix in der Provence," Vierteljahrsschr naturf. Gesellsch. Zurich. 1, pp. 1-40, 1856.

[3] See Scudder's "Fossil Butterflies," p. 14.

[4] Bulletins de la Société Entomologique de Franco, 1838, 51-52.

[5] Annales de la Soc. Ent. de France, ix., 371-4.

[6] See "Lepidoptera Exotica," plate 48, fig. 3 (1873), also Geol. Mag. Vol. x. 3, plate 1, fig. 3 (1873).

[7] See Scudder's "Fossil Butterflies," p. 37; also Révue et Magasin de Zoologie, 1871-2, pp. 66-72; also Geological Magazine, Vol. ix., 532-33.

[8] See Scudder's "Fossil Butterflies," pp. 51-53.

[9] Mr. Scudder, at page 70 of his "Fossil Butterflies," says, "Count Saporta writes me concerning this fossil, 'Cette empreinte ne provient pas des platrières même, c'est a dire les galeries qui servent à l'exploitation du Gypse; *mais d'une assise ou groupe des couches immédiatement inferieure.*"

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Coliates Proserpina. It appears to have been discovered in the strata immediately beneath the calcareous marls of the gypsum quarries, and is therefore the *oldest butterfly* from the *Tertiary* formations.

The fourth insect of this order from these deposits—*Thaites Ruminiana*—was first described by Professor Heer,[1] who observes of it, "closely allied to the genus *Thais* which belongs to the Mediterranean fauna." It is in the collection of Professor Heer, and has since been described and figured by Mr. Scudder.[2]

The remains of the fifth and last butterfly from the Tertiaries of Aix consist of a single forewing, which Mr. Scudder refers to some species belonging to the *Astyci.* Mr. Scudder describes the species as *Pamphilites abdita,*[3] and its remains are said to be in the Marseilles Museum.

It will be noticed that the remains of all the fossil butterflies, at present discovered, have been found at Radoboj, Rott, and Aix, *all* belonging to the Tertiary formations; that the remains of three species belong to the *Mayencian* or lower portion of the Middle Miocene; the remains of one species to the lignite beds of Rott, belonging to the *Aquitanian* or upper part of the Lower Miocene; and the remains of the other five species from the calcareous marls (or strata immediately below the same) of the gypsum quarries of the *Ligurian*, belonging to the Upper Eocene formation. It is, as Mr. Scudder observes, rather extraordinary that the Upper Miocene beds of Œningen—which, if we except the Amber, have furnished almost more insects than *all* the other formations of the world together, and which are more recent than any of those in which butterflies have been found—have yielded the remains of only one species of *Lepidoptera*, and none whatever of butterflies.

Three out of the *five* species whose remains have been discovered in the Eocene formations at Aix, are said to be now only represented in the Indo-Malayan regions; *one* is closely related to genera now found in the American tropics; and *one* is now represented by a genus confined to the Mediterranean district, within which Aix lies, and is therefore, as Mr. Scudder observes, "at home in its own resting place." One point of especial interest in relation to these butterflies, to which Mr. Scudder calls attention,

[1] Described by Heer in manuscript; see also "Recherches sur le Climat et la Végétation du pays Tertiaire," p. 205.
[2] See Scudder's "Fossil Butterflies," pp. 60-62.
[3] See Scudder's "Fossil Butterflies," pp. 66-69.

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is that in every case, except one, the remains of the plants, which in all probability served their larvæ for food, have been found in the same beds as the insects themselves; and even in this excepted instance, a plant allied to those upon which species of the genus now feed, is said to occur in the same strata.

The most recent investigations of the geological strata of this district, and their fossil insects, have been made by M. Oustalet; who, in 1874, published the result of his investigations in the second part of his "Recherches sur les Insectes fossiles des Terrains Tertiaires de la France." In this most important work (a copy of which I have had the honour of receiving from the author) M. Oustalet has expressed his intention of making as complete a study of the fossil insects of Provence, as Dr. Heer has of those of Œningen.[1] Some idea of the magnitude of the labours which M. Oustalet has undertaken may be formed from the fact, that although the work above mentioned contains some 347 pages, exclusive of six plates, the *Coleoptera* only are included in it. Of the insects of this order upwards of 80 species, referable to 13 families, are described and figured.

The *Carabidæ* are represented by 11 species, the *Staphylinidæ* by 19 species, the *Curculionidæ* by 32 species, and the *Chrysomelidæ* by 7 species.

With the exception of "the learned Zurich Professor," no other Palæontologist on the Continent of Europe has produced any works on this branch of science of greater importance than those of M. Oustalet.[2]

[3] M. Henri Daudet has recently obtained from the Aix deposits, a fossil larva of one of the *Satyridæ*, which he has named *Satyrites incertus*.

Middle Eocene.

To this period belong the marls and limestones of Monte Bolca, near Verona, in Italy.[4] Associated with these marls and lime-

[1] "C'est ce que M. Heer a fait pour les Insectes d'Œningen et c'est ce que j'essayerai de faire dans le chapitre suivant, pour les Insectes des gypses de la Provence, en suivant la voie qui a été si brillament tracée par le savant Professeur de l'Université de Zurich." "Recherches sur les Insectes fossiles," &c., pt. 2, p. 74.

[2] M. Oustalet is, I believe, now engaged on a description of the fossil insects of other orders from the same district.

[3] "Revue et Magasin de Zoologie." 3e Série T. 4e 1876, p. 415-424. See also "Petites Nouvelles Entomologiques," No. 145.

[4] See Lyell's "Elements of Geology," 6th edit., p. 687.

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stones are beds containing lignite and shale, which have been described by Professor Unger and Signor Massalongo, and referred by them to the same period. M. Marcel de Serres[1] alludes to the discovery at Monte Bolca, by Scheuchzer, of some *Neuropterous* insect of the genus *Libellula*. Scheuchzer's notice of this insect is also alluded to by Signor Massalongo,[2] who, in 1856,[3] described and figured seven fossil insects from this locality, referable to the following orders:—

	Species.		Species.
Coleoptera	2	Neuroptera	2
Orthoptera	1	Diptera	2

Although so few insects have been found in these deposits, they have been for centuries celebrated for their fossils, especially *Ichthyolites*.[4]

AMERICAN STRATA.

Recent or Post Tertiary.

In the 5th volume of the "Transactions of the American Entomological Society"[5] Dr. G. H. Horn describes certain *Coleopterous* remains discovered in cave deposits (belonging to the Post Pliocene period) at Port Kennedy, Pennsylvania. From these remains[6] Dr. Horn has identified some ten species of *Coleoptera*.

[1] "Il parait que l'on trouve également des insectes fossiles dans les Marnes calcaires fluviatiles de Monté Bolca dans le Veronnais. Du moins. Scheuchzer cite-t-il des *Libellules* avec leur ailes étalées qui selon lui en provenaient." "Géognosie des Terrains Tertiaires," &c., p. 234.

[2] Che io mi sappia Scheuchzer fu il primo che ci parlasse come comportavano le scienze a suoi giorni, di un insetto fossile del M. Bolca, nel suo *Herbarium Diluvianum*, dove una *Cordulia*, (?) che ebbe in dono dal suo amico Vallisnieri si trova descritta e figurata. "Studii Paleontologici," p. 12.

[3] *Op. cit.*, pp. 11-21.

[4] Note.—Since the date of this paper (1st June, 1877) Professor Rupert Jones, F.R.S., has informed me that a quantity of insect remains have been obtained from Serzanne (Marne), France, in fresh-water limestone of *Lower* Eocene date; and that, when in Paris, he saw some delicate plaster casts of these insects, which had been made by Professor E. Hébert and his assistants, at the Sorbonne. Remains of plants from this formation were described by Count Saporta in 1868, but I have not been able to find any description of the insects.

[5] "Trans. American Ento. Soc." Vol. v., pp. 241-245. I am indebted to Mr. R. M'Lachlan, F.R.S., for calling my attention to this paper.

[6] Since this paper was read, on the 1st June last, Mr. S. H. Scudder has described two new species of *Carabidæ* found in the inter-glacial deposits of Scarborough Heights, near Toronto, Canada. One species has been named by Scudder *Loricera glacialis* and the other *Loxandrus gelidus*.—See the "Bulletin of the United States Geological and Geographical Survey," Vol. iii., No. 4. August, 1877.

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TERTIARY.

The earliest discoveries of fossil insect remains from the American Tertiary formations, appear to have been made several years ago by Professor Denton,[1] in shales in Colorado, near the junction of the Green and White Rivers. They are said to have been found in two distinct localities sixty miles apart, the specimens in one place differing from those of another, not only specifically, but in their general character. Subsequent investigations in other parts of the same region have since been made by Mr. F. C. A. Richardson, and also by Dr. Hayden. In a letter to the editors of the "American Naturalist,"[2] Mr. Richardson says:—"I discovered and collected the fossil insects on the Green River in Wyoming territory, on the line of the Union Pacific Railroad, some 40 miles this side (east) Salt Lake City; or, to be more precise, the locality is five miles west of Green River City, and on the railroad track. The shale, or portion of shale, in which the insects were found runs in a circle from the N.E. to the S.W., as if on the border of a small lake. I also noticed that the fish are not in regular order, as the insects, which cover a space about two feet wide, and form a ring or belt around the lake."

On the subject of the insects discovered by Mr. Richardson, Mr. Scudder says[3]—"About 100 slabs, mostly of very small size, were brought away; these contained at least 175 specimens, including in that number all the reverses. Of these specimens, 35 cannot be referred with certainty to any subordinal group, since they consist merely of abdominal segments, or blurred and distorted fragments, the affinities of which can only be rudely surmised. The remainder are referable to nearly 40 species belonging to the following groups, mainly arranged in the order of numerical superiority:—

		Species.			Species.
Diptera	66 specimens	= 13	Hemiptera	4 specimens	= 2
Coleoptera	52 „	= 12	Orthoptera	4 „	= 2
Hymenoptera	5 „	= 3	Neuroptera	2 „	= 2

[1] See "Proceedings Boston Society of Natural History," Vol. xi., 117-118; also the "American Naturalist," Vol. vi., for Nov., 1872.

[2] See Vol. vi.

NOTE.—I have thought it advisable to refer to the American Tertiary formations, and their fossil insect remains, after concluding my observations on the European formations of this period, especially as I am unaware whether the American strata should be referred to the Pliocene, Miocene, or Eocene divisions of this period.

[3] See Mr. Scudder's paper in Vol. vi. of the "American Naturalist" for November, 1872.

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"Of the *Diptera*," continues Mr. Scudder, "one half of the specimens belong to single, or possibly two heavy-bodied species of small size, which although invariably wingless, are presumed to be so only by mutilation, since exceedingly few wings are preserved on any of the stones; of the other half two-thirds are *Tipulidæ* or *Mycetophilidæ*, and include five of the species, while the remaining sixth comprises about half the species and belongs to various groups. Of the *Coleoptera* fully one-half the species, and about $\frac{7}{10}$ths of the specimens belong to the *Curculionidæ*; the others mostly to the *Staphylinidiæ* and *Carabidæ*.

"The *Hymenoptera* consist of a small ant, and a *Pteromalus* like insect, and one rather obscure form. The *Hemiptera* are represented by an insect resembling *Issus*, and another apparently belonging to the *Tingidæ*. In the *Orthoptera* there are only legs of a Locustarian, about as large as our common *Phylloptera*, and a cricket, perhaps, of the genus *Nemobius*. Two *Phryganeids* are represented by wings, one of them doubtfully located in this family."

The insects discovered by Mr. Richardson are said to be entirely different from those found by Professor Denton. Mr. Scudder observes—"Comparing the assemblages of species, we find that *Diptera* and *Coleoptera* are the prevailing forms in each; but that within these groups the types differ in a remarkable manner according to their several localities; the *Orthoptera* and *Neuroptera* of the later discovered beds are wholly wanting in the earlier; the [1]*Lepidoptera* and *Physopoda* are found only in Fossil Canon, and no traces of ants appear in Chagrin Valley, though occurring in the other two places, and also in the locality examined by Dr. Hayden."[2]

Quite recently Mr. [3]Scudder has published a description of two species of *Orthopterous* insects from the Rocky Mountain Tertiaries, one of which was found by Mr. T. L. Mead at Castello's Ranch, South Park, Colorado; and the other was found in the same

[1] This turns out to be a mistake. In a subsequent paper (August 1877), Mr. Scudder says "there are no *Lepidoptera* in the collection (nor have I yet seen any from America), the supposed Noctuid proving to be one of the *Syrphidæ*, badly preserved, and the possible slug-caterpillar a Dipterous larva."

[2] The *Coleoptera* were described by Mr. Scudder in the "Bulletin of the U.S. Geological and Geographical Survey of the Territories,' Vol. ii., No. 1, March, 1876; the remainder of the insects in this collection have been described by Mr. Scudder since the date on which this paper was read, in the "Bull. U.S. Geol. and Geogrp. Survey," Vol. iii., No. 4, August, 1877.

[3] See a paper on "Fossil Orthoptera from the Rocky Mountain Tertiaries," in the "Bulletin of the Geological and Geographical Survey of the Territories," No. 6, 2nd series (Washington, February, 1876).

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locality, by Mr. Jesse Randall. The first species Mr. Scudder has described as *Homœogamia ventriosus*, and the latter as *Labidura tertiaria*.

Since the date of the last-mentioned paper, Mr. Scudder[1] has published detailed descriptions of 31 species of *Coleoptera*, most of which were included in those before referred to as having been found by Professor Denton and Mr. Richardson; and a few others of which were found by Mr. Mead, or by members of the United States Geological Survey. "In this paper," says Mr. Scudder, "are made known the first fossil *Coleoptera* from the Tertiaries of the United States; indeed, if we except some doubtful remains found in the red sandstone of the Connecticut Valley, the first distinctively American *Coleoptera* from any formation. Two beetles have been figured by Heer from the Miocene of Northern[2] Greenland, and these are all that have yet been described from the New World."

These valuable contributions to our knowledge of the fossil insects of the American Tertiaries were alluded to by Professor Westwood, in his [3]Anniversary Address to the Entomological Society of London, on the 7th February, 1877. Mr. Scudder[4] has very recently described several species of insects obtained by Mr. G. M. Dawson from Tertiary beds at Quesnel, British Columbia. In addition to fragmentary indeterminate remains, there are some 24 species distributed among the undermentioned orders as follows :—

Coleoptera	1		Hemiptera	1	
Neuroptera	1		Diptera	14	
Hymenoptera	7				

Amber.

Nowhere have fossil insects been found in [5]greater numbers, or in a more beautiful state of preservation, than in "that resinous and bitumenous substance known as Amber."

[1] See a paper on "Fossil Coleoptera from the Rocky Mountain Tertiaries," in the "Bulletin of the Geological and Geographical Survey of the Territories," Vol. 2, No. 1 (Washington, March 21, 1876).

[2] In 1868 Dr. Oswald Heer described four insects from the Miocene of North Greenland. (See Flora Fossilis Arctica, 129-130.)

[3] See the Anniversary Address to the Entomological Society of London, on the 7th February, 1877, by Professor Westwood, M.A., F.L.S.

[4] See Report of Progress, 1875-1876—"Geological Survey of Canada."

[5] See "Traité elémentaire de Paléontologie," by F. J. Pictet. Vol. iv., p. 97.

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The origin of Amber has been the subject of much controversy. Some ancient writers attributed it to Ants, and some considered it to be of mineral origin. It is now considered, by all authorities, to be of vegetable origin, and to have been formed from the resin which distilled from the trunks of certain species of *Coniferæ* of the Tertiary epoch,[1] whose fossilized remains form the beds of lignite in which it is frequently obtained.

In some cases the leaves of the *Coniferæ* have been found in Amber; and although, according to Dr. Bérendt, they appear to differ from all known species, he thought himself justified in ascribing them to the genus *Pinus*. With reference to his opinion, the Rev. F. W. Hope observes[2]—"In a letter lately received from Dr. Bérendt, he informs me that the anotomico-microscopical examination of the wood places it beyond a doubt that the Amber was a *Pinus;* but of what species cannot be now known; but that *Pinus balsamea* approaches nearest to it in appearance."

Amber is said to be occasionally thrown on the beach of the Eastern coasts of England, along with masses of jet; and if not torn from the bed of the sea, may have been washed from the Baltic, where, according to Dr. Bérendt, the geographical focus of the Amber wood was situated. Speaking of its occurrence on the Eastern Coasts of this country, Mr. Brodie[3] observes that, "although the communication between the Baltic Sea and the German Ocean is broken by the land of Denmark, and only exists through the Island of Zealand, and other islands which lie between Denmark and Sweden, it is quite possible, and by no means improbable, that currents may have conveyed pieces of Amber from the coasts of the Baltic, through the Cattegat, into the North Sea, and thence they would occasionally, though rarely, be picked up on our Eastern Coasts." They may perhaps have been brought thence during the Post Tertiary[4] period, when what is now the land of Denmark was depressed[5] beneath the ocean, and the North Sea and the Baltic formed one uninterrupted expanse of water.

[1] Pictet *op. cit.*, Vol. iv., p. 98.

[2] Rev. F. W. Hope, F.R.S., &c., on "Succinic Insects," Trans. Ent. Soc., London I., Part 3, pp. 133-147.

[3] See Brodie's paper "On the nature and origin of Amber," in the 35th Annual Report of the Warwickshire Natural History Society (April, 1871).

[4] (?) Upper Miocene Period.

[5] See the map at the end of Heer's "Recherches sur le Climat et la Végétation du pays Tertiaire."

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Amber is also abundant on the shores of Sicily[1] and the Adriatic Sea ; also in the beds of lignite or brown coal in Germany and Prussia, and it is occasionally found in Spain, France, Russia, Africa, and Brazil. Mr. Hope says that it has been found in the gravel pits near London; and Mr. Brodie states that he has detected small pieces of resin in the clays of the Wealden, in the Isle of Wight.

Professor Heer observes[2] that Amber is found not only on the coasts of the Baltic Sea, from Kœnigsberg to the Eastern coasts of Jutland ; but also, although much more sparingly, on those of the North Sea (at Heligoland) ; on the Western coasts of France ; in Iceland and in Greenland; then in another direction in the North of Siberia as far as Kamtschatka ; it is found also in the Tertiary formations of the interior, in the grit or sandstone of Gallicia ; and, according to M. K. Mayer, in the blue marls of the Pliocene formation of Castel-Arquato; it is met with also in the lignites of Lobsann, in Alsace, at Schienerberg, near Œningen, and in Sicily.

One of the richest deposits of Amber, is in that part of the province of Prussia called Samland, which is bounded on the west and north by the Baltic. In some parts of this district, according to [3]Professor Zaddach, fine sections of the Tertiary strata (at a height of from 80 to 125 feet above sea level) are exposed. The lower portion of these strata is said to consist of beds of Glauconitic sand, overlaid by the brown coal formation, from 60 to 100 feet thick. The lower portion of the Glauconite sand, says Zaddach, is cemented, by hydrated oxide of iron, into a coarse sandstone, which contains numerous fossils; below this is a deposit of finer quartz grains and more Glauconite and clay and mica; associated with the above, in descending order, is a wet sandy stratum called quicksand, succeeded by a blue earth—fine-grained and argillaceous. In this the Amber is found abundantly, but generally in small pieces. Above and below the Amber earth only a few isolated pieces of Amber occur. Mr. Brodie observes that the species of fossil shells discovered in this Amber earth, determine the age of these strata to belong to the Eocene, or oldest formation of the Tertiary period.

[1] M. Oustalet observes that Amber is found in the blue marls referable to the Pliocene period at Castel-Arquato in Sicily.

[2] "Recherches sur le Climat et la Végétation du pays Tertiaire," p. 113.

[3] See a translation of Professor Zaddach's paper in the April Number of the "Quarterly Journal of Science" for 1868.

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Some portion of the Amber, found in such quantities in this province of Samland, was probably formed in the vast pine forests of the Scandinavian peninsula, and then washed down by the rivers flowing therefrom into the German continent. In order to understand this theory, it must be remembered that the Scandinavian peninsula is believed not to have been entirely separated from the German continent, during the Tertiary period, by the Baltic Sea, as at the present day; but to have been connected with the continent by a [1]neck of land, many miles in width, extending from the neighbourhood of Kœnigsberg to that of Dantzic. In no other way can we account for the fact that the Prussian Amber contains remains of the Scandinavian flora mingled with that of the Sub-Alpine type.

Professor Zaddach[2] is of opinion that the Tertiary Glauconite was derived from the green sand of the older cretaceous formation, the younger beds of which constitute a part of the Danish Island of Bornholm. He is also of opinion that the trees which yielded the Amber, must have grown upon the green sand beds of the cretaceous period, flourishing luxuriantly upon the marshy coasts which then surrounded the great continent of Northern Europe.

There appears to be the very best possible evidence that all Amber was not formed during one and the same epoch.[3] Professor Heer[4] says that the Amber of Kleinkuhren belongs to the Upper Eocene period, while some is found in strata referable to the Lower Miocene period ; and that the Amber of the lignites of Lobsaun, and that of the blue marls of Castel-Arquato (Pliocene), proves that the trees which produced it existed throughout the Tertiary epoch.

The long period throughout which the Amber-producing trees existed, and their geographical distribution, accounts for the fact that in the plants and insects discovered in Amber, the mixture of Northern and Southern forms is much more striking than in

[1] See map at the end of Heer's "Recherches sur le Climat," &c.

[2] "Quarterly Journal of Science" for April, 1868.

[3] M. Gœppert appears to have considered Amber as belonging to the Pliocene period, from his having identified no less than 30 species of plants found therein, with existing species. See "Die Bernstein-flora, Monats bericht der Berliner Academie," 1853. Dr. Heer refers the strata at Samland, from which the Amber is obtained, to the *upper section of the Upper Eocene*, and the *upper section of the Lower Miocene*. "Recherches sur le Climat," &c., p. 111-112.

[4] Op. cit p. 114.

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any one European formation of the Tertiary period; and why many types are there met with belonging to high latitudes, as well as types of mountain species; *e.g.*, the insects and spiders from Amber include, says Heer, types of the tropical and subtropical zones, such as *Termites*, *Pœocera*, *Halobates*, *Polyzosteria*, *Passandra*, *Plecia*, *Sylvius*, *Hersilia*, *Chauliodes*, *&c.*, and also Northern forms, such as *Mochlonyx* and *Gloma*.

Amongst the very numerous authorities which I have consulted on the subject of Amber, and its organic remains, considerable difference of opinion appears to prevail as to the proportion of the specimens, detected in Amber, which belong to extinct genera and species; but, by far the greatest number of authorities, including Hope, Koch, Germar, Pictet, Hagen, Lœw, and Menge, appear satisfied that amongst the many thousands of insects and spiders found in Amber, all of them, with the exception of a very small number, are different from living species; though many of them are closely allied to, and may be considered as analogous with, species now living. On this subject Mr. Hope observes, "The insects at present detected in Amber appear to relate to species extra European, many of them belonging to tropical climes[1]; while some approach South American and Indian forms. They do not appear related to any existing species, and are, therefore, probably extinct, and this seems to be the opinion of Germar, Jussieu, De Jean, Dr. Leach, and others."

Professor Pictet, who has paid special attention to the remains of *Neuroptera* in Amber, is of the same opinion. Amongst the *Neuroptera* he recognises: firstly, species allied to, but not identical with, those existing in Prussia at the present day; secondly, intertropical and Mediterranean species; thirdly, exotic types; fourthly, certain extinct species without any representatives at the present day.

On the other hand,[2] Dr. Burmeister states that the families, genera and species of insects, found in Amber, present a conformity, in the majority of instances, with existing forms, and

[1] Quant aux insectes disséminés dans le Succin, on a avancé que généralement, ils ont plus de rapport aux éspèces des climats chauds, qu, à ceux des régions tempérés, et, par conséquent ils sont, pour la plupart, étrangers aux climats de la Prusse et de la Poméranie ou le succin insectifère se trouve en grande quantité, si ce n'est pas dans son véritable gîte. Marcel de Serres "Géognosie des Terrains Tertiaires." Livre iv.me. p. 238.

[2] Burmeister's "Manual of Entomology," p. 575.

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even an identity of species; and that no new forms have been observed, and existing genera are readily recognised.

Professor Westwood states that in the Taylor Museum, at Oxford, are several insects, in Amber, from Catania, in Sicily; and that they are very interesting and different to those of the Baltic: he also adds that the insects figured and described by Dr. Bérendt are, many of them, very like the insects of the present time.

The remains of insects in Amber are very numerous. Swammerdamm is said to have had in his collection 166 specimens of *Coleoptera*, and Frisch more than 200. Dr. Bérendt had over 1,000 specimens, among which, however, were many duplicates.

The number of species of the different orders of insects discovered in Amber, and enumerated by Mr. Hope, in the list at the end of his paper on "Succinic Insects," is as follows:—

Of the Coleoptera[1]	about	160	species.	Of the Orthoptera	about	12	sp.
„ Homoptera	„	11	„	„ Hemiptera	„	15	„
„ Neuroptera	„	10	„	„ Lepidoptera (Papilio)		10	„
„ Hymenoptera	„	25	„	„ Diptera	„	22	„

Mr. Hope also gives a list[2] of insects from Copal and Animé, which includes:—

Coleoptera	9 species.	Hemiptera	1 species.
Hymenoptera	2 „		

In his "Fauna der Vorwelt,"[3] Dr. Giebel enumerates 318 species from Amber, viz.:—

Coleoptera	106 species.	Neuroptera	28 species.
Hymenoptera	14 „	Orthoptera	4 „
Lepidoptera	3 „	Hemiptera	22 „
Diptera	141 „		

With regard to the ten species of *Lepidoptera* enumerated in the lists compiled by Mr. Hope, it may be observed that it is doubtful whether they included any butterflies, because the generic term "*Papilio*" made use of therein, was anciently applied to all *Lepidoptera*, both *Rhopalocera* and *Heterocera*.

[1] See Hope's paper on "Succinic Insects," Transactions of the Ent. Soc., Lond., Vol. i, pt. 3, 133-147. Bérendt's "Die Insekten in Bernstein." Burmeister's "Handbüch der Entome." A Monograph by Dr. Bérendt in the Memoirs of the Ent. Soc. France, t. v. p. 539, and Pictet's "Paléontologie," Vol iv, pp. 97-144.

[2] See Transactions Ent. Soc., Lond, Vol. ii, pp. 46-57.

[3] "Fauna der Vorwelt" (Insekten and Spinnen), pp. 393-426.

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Mr. Scudder is of opinion that the probable nature of the ancient forest of Amber renders it unlikely that any butterflies, in their perfect state, could be found in it; he states, however, that Dr. Hagen had informed him that he had himself seen specimens of large butterflies in Amber, but that they proved to be *falsifications*, recent European insects, like *Pieris Rapæ*, having been enclosed between slabs of it, which were then fastened together, and the edges roughened, in so clever a manner that no one would have suspected them to be spurious.[1]

With this imperfect notice of Amber, and the insect remains detected therein, I must bring this paper to a conclusion.

The second paper of the series will be devoted to the Insect Fauna of the Secondary or Mesozoic Period, and the British and Foreign Strata in which their remains have been detected. In the third paper I shall describe the insect remains from the British and Foreign Strata of the Primary or Palæozoic Period, and shall conclude with some general observations as to the deductions which may be drawn from a study of Fossil Insects.

A LIST OF INSECT REMAINS DISCOVERED IN THE FORMATIONS OF THE RECENT OR POST TERTIARY PERIOD.

BRITISH STRATA.

Peat and Brick-earth, Lexden Brick Pit, Lexden, near Colchester[2]:—

Remains of *Coleoptera*; including *Cassididæ*, *Coccinellidæ*, *Chrysomelidæ*, *Curculionidæ*, *Carabidæ* and *Buprestidæ*.

Boulder formation or drift of the Cliffs of Eastern Norfolk[3]:—

[1] Pictet observes, "Il faut aussi se défier beaucoup de contrefaçons exécutées dans divers pays dans le but d'un gain illicite." Traité de Paléontologie, Vol. iv., p. 99.

NOTE.—For further information on Insects in Amber, see Bromell's "Lithographia Suecana Acta litteraria Sueciæ," 1729.

"Historia Succinorum aliena involventium," Lipsiæ, 1742, by Sendelius.

"Géognosie des Terrains Tertiares," &c., 1829, by Marcel de Serres.

Observations on Succinic Insects, by the Rev. F. W. Hope, F.R.S., in the transactions of the Entomological Society, London, Vol. i., 1834.

"Lethea Géognostica," &c., Vol. ii., p. 811, by H. G. Bronn, 1835.

"Handbüch der Entomologie," by Dr. Burmeister.

"Die Insekten in Bernstein," by Dr. G. C. Bérendt.

"Insectes dans l'ambre," Ehrenberg.

[2] See page 12 ante.

[3] See page 13 ante.

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Elytra of *Coleoptera;* including two species of *Donacia*; an *Elater;* an elytron of one of the *Harpalidæ;* and an elytron of *Copris Lunaris.*

FOREIGN STRATA.

Lignites of Uztnach and Dürnten, in Switzerland [1] :—

A coleopterous insect allied to *Feronia leucophthalma*, another similar to *Callidius fennicum.*

Elater æneus?	Pterostichus nigrita,
Donacia discolor?	Carabites diluvianus,
„ sericea?	„ cordicollis.
Hylobius rugosus,	

Elsinore [2] :—

Cervus longirostris,	Buprestidæ, &c.
Aphodius fossor,	

A LIST OF INSECT REMAINS DISCOVERED IN THE FORMATIONS OF THE TERTIARY PERIOD.

BRITISH STRATA.

LOWER MIOCENE.

Neighbourhood of Antrim, Ireland [3] :—Elytra of two species of *Coleoptera.*

Lignites and clays of Bovey Tracey :—*Buprestes Falconeri.*

UPPER EOCENE.

Eocene Freshwater limestone of Gurnet Bay, Isle of Wight:—

Remains of *Diptera*, including wings of *Tipulidæ* and *Culicidæ* [4] —

One wing of a *Hemipterous* insect.

1 *Homopterous* insect identified as *Triecphora sanguinolenta.*

2 Specimens of *Lepidoptera* (*Lithosia*).

3 *Orthoptera* (one a *Gryllotalpa*).

[1] "Urwelt der Schweiz" and Oustalet's "Recherches sur les Insectes fossiles, &c."

[2] Bull. Soc. Geol. France, t. ix., p. 114.

[3] See Mr. Brodie's paper on the distribution and correlation of Fossil Insects, and Mr. Judd's paper on the Volcanic Rocks of Scotland, "Geological Journal," August, 1874, Vol. xxx., No. 119, p. 274.

[4] "Nature," for December, 1874 (Vol. xi). A'Court Smith in litt: and Abstracts (No. 343) of the "Proceedings of the Geological Society of London" (Session 1877-78).

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12 *Coleoptera* (including *Hydrophilus, Dyticus, Curculio, Anobium, Dorcus*, and *Staphylinus*).

35 wings of *Hymenoptera* (including *Myrmica, Formica*, and *Camponotus*).

23 specimens of *Neuroptera* (including *Termes, Perla, Libellula, Agrion, Phryganea* and *Hemerobius*).

Middle Eocene.

Creech Leaf beds, Corfe, Dorset:—

Elytra of *Buprestidæ*.

„ of *Helopidæ*.

„ of *Curculionidæ*.

Bournemouth Leaf beds:—

Elytra of *Coleoptera, Hymenoptera, Neuroptera, &c.*

Lower Eocene.

London clay near Parkhurst, Isle of Wight[1]:—Elytra of *Coleoptera*.

Paludina beds at Peckham,[2] London:—Elytra of *Coleoptera*.

FOREIGN STRATA.

The following list, compiled from "Recherches sur le Climat et la Végétation du Pays Tertiaire," (the French translation, by Dr. Gaudin, of Professor Heer's "Untersuchungen über das Klima und die Végétations Verhaltnisse des Tertiärlandes") will show the names of the orders, groups, and families of insects, obtained from the Œningen strata, from Radoboj, and from the Swiss Molasse, and the number of species comprised in each family.

Upper Miocene.

Œningen.

Coleoptera.—518 species.

		Species.			Species.
I.	[3]Geodephaga	... 54	II.	Hydradephaga	... 12
	Carabidæ	... 54		Dyticidæ	... 12

[1] Mantell's "Geology of the Isle of Wight," p. 101.

[2] "Geologist," January, 1861, pp. 39-40.

[3] In this list I have adopted the arrangement of Professor Heer and Dr. Gaudin, but I have altered the *terminations* of the names to those used by Waterhouse in his "Catalogue of British Coleoptera," or by Pascoe in his "Zoological Classification."

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	Species.		Species.
(III. [1]GYRINIDA) ...	2	Lymexylonidæ ...	1
Gyrinidæ ...	2	XI. HETEROMERA—	
IV. BRACHELYTRA ...	10	(MELANOSOMATA) ...	5
Protactidæ? ...	2	Stenosidæ ...	1
Staphylinidæ ...	4	Tenebrionidæ ...	3
Oxytelidæ ...	2	Opatridæ ...	1
Aleocharidæ ...	2	(XII. TRACHELIDA?) ...	4
V. [2]NECROPHAGA—		Cantharidæ ...	4
(CLAVICORNIA) ...	55	(XIII. STENELYTRA) ..	19
Scaphidiidæ ...	2	Helopidæ ...	6
Silphidæ ...	1	Cistelidæ ...	9
Nitidulidæ ...	17	Œdemeridæ ...	2
Peltidæ ...	15	Lagriadæ ...	1
Rhysodidæ ...	1	Anthicidæ ...	1
Byrrhidæ ...	5	XIV. LONGICORNIA ...	30
Dermestidæ ...	2	Prionidæ ...	7
Histeridæ ...	12	Cerambycidæ ...	14
VI. PALPICORNIA ...	22	Lamiidæ ...	8
Hydrophilidæ ...	22	Undetermined species ...	1
VII. LAMELLICORNIA ...	42	XV. XYLOPHAGA ...	2
Geotrupidæ ...	2	Hylesinidæ ...	2
Copridæ ...	14	RHYNCHOPHORA ...	108
Hybosoridæ ...	1	Bruchidæ ...	3
Aphodiidæ ...	4	Anthribidæ ...	6
Dynastidæ ...	1	Attelabidæ ...	13
Melitophilidæ ...	9	Antliarhinidæ ...	1
Glaphyridæ ...	2	Cycladæ ...	1
Melolonthidæ ...	9	CURCULIONIDÆ	
VIII. STERNOXI ...	67	Brachyceridæ ...	3
Buprestidæ ...	40	Brachyderidæ ...	6
Elateridæ ...	27	Cleonidæ ...	17
IX. MALACODERMI [3] ...	14	Molytidæ ...	15
Lycidæ ...	1	Pristorhynchidæ ...	1
Lampyridæ ...	1	Erirhinidæ ...	19
Telephoridæ ...	5	Cryptorhynchidæ ...	9
Melyridæ ...	7	Calandridæ ...	3
(X. TEREDYLA?) ...	3	Cossonidæ ...	1
Tillidæ? ...	2	Undetermined species ...	10

[1] Where the name of a group standing by itself, and not as a second name, is in brackets, such a group is not recognised in any system of classification adopted in this country; and it is retained merely to show the division of the groups, and the arrangement of the families in the work above mentioned.

[2] Where two names are given to a group, the upper one is that generally in use in this country, and the second name, in brackets, is the equivalent for the name used by Gaudin in the work above mentioned.

[3] I prefer *Mulacodermata*, but Waterhouse and Pascoe make it *Malacodermi*.

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	Species.
XVI. EUPODA — (CHRYSOMELINA)	... 50
Donaciadæ	... 2
Hispidæ	... 4
Cassidiidæ	... 8
Crioceridæ	... 1
Clythridæ	... 2
Eumolpidæ	... 1
Chrysomelidæ	... 15
Galerucidæ	... 9
Undetermined species	... 8
XVII. PSEUDOTRIMERA—(COCCINELLIDA)	... 19
Coccinellidæ	... 19

ORTHOPTERA.—20 Species.

	Species.
I. EUPLEXOPTERA—(DERMAPTERA)	... 3
Forficulidæ	... 3
II. CURSORIA	... 2
Blattidæ	... 2
III. GRESSORIA—(RAPTORIA)	... 1
Mantidæ	... 1
IV. SALTATORIA	... 12
Locustidæ	... 3
Acridiidæ	... 7
Gryllidæ	... 2
V. THYSANOPTERA	... 2

NEUROPTERA.—27 Species.

	Species.
I. CORRODENTIA	... 4
Termitidæ	... 4
II. SUBULICORNIA	... 21
Ephemeridæ	... 1
Libellulidæ	... 20
III. TRICHOPTERA	... 2
Phryganeidæ	... 2

HYMENOPTERA.—80 Species.

	Species.
I. MELLIFERA (ANTOPHILA)	... 14
Apidæ	... 14
II. PRÆDONIA	... 50
Vespidæ	... 1
Formicidæ	... 44
Scolidæ?	... 1
Sphegidæ?	... 4
III. PUPIVORA (ENTOMOPHAGA)	... 13
Ichneumonidæ	... 12
Chalcididæ	... 1
IV. TEREBRANTIA (PHYTOPHAGA)	... 3
Tenthredinidæ	... 3

LEPIDOPTERA.—3 Species.

	Species.
NOCTURNI	... 3
Bombycidæ	... 3

DIPTERA.—63 Species.

	Species.
I. TIPULARIA	... 51
Chironomidæ	... 5
Gallicolæ	... 1
Tipulidæ	... 2
Mycetophilidæ	... 15
Floralidæ?	... 28
II. NOTACANTHA	... 2
Xylophagidæ	... 2
III. TANYSTONATA	... 4
Asilidæ	... 3
Tabanidæ	... 1
IV. BRACHYCERA	... 2
Syrphidæ	... 2
(V. ATHERICERA)	... 4
Muscidæ	... 4

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HEMIPTERA.—133 Species.

	Species.		Species.
I. HETEROPTERA		(II. HYDROCORÆ) ...	6
(GEOCORÆ) ...	108	Nepidæ ...	5
Scutelleridæ ...	6	Notonectidæ ...	1
Pentatomidæ ...	39	III. CICADINÆ ...	15
Coreidæ ...	18	Stridulantiæ ...	1
Lygæidæ ...	23	Fulgoridæ ...	1
Capsidæ ...	2	Membracidæ ...	1
Tingidæ ...	2	Cicadellinæ ...	12
Reduviidæ ...	17	IV. PHYTOPHTHIRIA	
Hydrometridæ ...	1	Aphidæ ...	3

Total number of species of all Orders from the Œningen Strata—844.

NOTE.—I am indebted to Mr. C. O. Waterhouse, of the British Museum, for suggesting certain alterations in some of the names used in the above list.

MIDDLE MIOCENE.

Radoboj.

COLEOPTERA.—42 Species.

	Species.		Species.
I. GEODEPHAGA ...	5	VII. MALACODERMI ...	4
Carabidæ ...	5	Telephoridæ ...	3
II. HYDRADEPHAGA ...	1	Melyridæ ...	1
Dyticidæ ...	1	(VIII. TRACHELIDA?) ...	1
III. BRACHELYTRA ...	4	Cantharidæ ...	1
Omalidæ ...	1	IX. LONGICORNIA ...	3
Staphylinidæ ...	2	Cerambycidæ ...	1
Oxytelidæ ...	1	Lamiidæ ...	2
IV. NECROPHAGA—(CLAVICORNIA) ...	10	X. RHYNCHOPHORA ...	2
Silphidæ ...	1	Brenthidæ ...	1
Nitidulidæ ...	6	Undetermined species ...	1
Peltidæ ...	3	XI. EUPODA — (CHRYSOMELINÆ) ...	5
V. PALPICORNIA ...	1	Eumolpidæ ...	1
Hydrophilidæ ...	1	Chrysomelidæ ...	3
VI. STERNOXI ...	4	Gallerucidæ ...	1
Buprestidæ ...	3	XII. PSEUDOTRIMERA—	
Elateridæ ...	1	(COCCINELLIDA) ...	2

ORTHOPTERA.—13 Species.

	Species.		Species.
I. EUPLEXOPTERA		III. SALTATORIA ...	11
(Dermaptera) ...	1	Locustidæ ...	3
Forficulidæ ...	1	Acridiidæ ...	8
II. GRESSORIA			
(Raptoria) ...	1		
Mantidæ ...	1		

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NEUROPTERA.—19 Species.

		Species.			Species.
I.	CORRODENTIA	... 10	III.	TRICHOPTERA	... 1
	Termitidæ	... 10		Megalopteræ	... 1
II.	SUBULICORNIA	... 8			
	Libellulidæ	... 8			

HYMENOPTERA.—85 Species.

		Species.			Species.
I.	MELLIFERA (ANTOPHILA)	... 3	III.	PUPIVORA (ENTOMOPHAGA)	... 22
	Apidæ	... 3		Ichneumonidæ	... 22
II.	PRÆDONIA	... 59	IV.	TEREBRANTIA (PHYTOPHAGA)	... 1
	Vespidæ	... 1		Uroceridæ?	... 1
	Formicidæ	... 57			
	Sphegidæ	... 1			

LEPIDOPTERA.—8 Species.

		Species.			Species.
I.	DIURNI	... 3	II.	NOCTURNI	... 5
	[1] Nymphalidæ	... 2		Noctuidæ	... 2
	[2] Pieridæ	... 1		Geometridæ (Phalænidæ)	... 2
				Pyralidæ	... 1

DIPTERA.—Species 83.

		Species.			Species.
I.	TIPULARIA	... 56	III.	TANYSTONIA	... 4
	Chironomidæ	... 1		Asilidæ	... 3
	Tipulidæ	... 14		Anthracidæ	... 1
	Mycetophilidæ	... 13	IV.	BRACHYCERA	... 9
	Floralidæ?	... 28		Syrphidæ	... 9
II.	NOTOCANTHA	... 1	(V.	ATHERICERA)	... 12
	Xylophagidæ	... 1		Muscidæ	... 12

HEMIPTERA.—61 Species.

		Species.			Species.
I.	HETEROPTERA (GEOCORÆ)	... 33	II.	CICADINÆ	... 23
	Pentatomidæ	... 13		Stridulantiæ	... 3
	Coreidæ	... 5		Fulgoridæ	... 1
	Lygæidæ	... 9		Cicadellinæ	... 19
	Tingidæ	... 2	III.	PHYTOPHTHIRIA	... 5
	Reduviidæ	... 4		Aphidæ	... 5

Total number of species of all Orders from the Radoboj Strata—312.

In the "Nova Acta" of the Academy of Leopold Charles, of

[1] Eugonia Atava. Mylothrites Pluto.
[2] Pontia Freyeri.

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Austria, for 1839, vol. xix., Professor Unger describes eight species from this locality (Radoboj), viz :—

Rhipidia extincta.	Bibio lignarius.
„ major.	„ giganteus.
Bibio Murchisonis.	„ enterodeles.
„ gracilis.	Leptogaster Hellii.

In the "Nova Acta," &c., for 1843 (vol. xx.), Von Charpentier describes seven species from the same locality, viz. :—

Œdipoda melanosticta.	Sphinx atavus.
Myrmeleon brevipenne.	Hylotoma cineracea.
„ reticulatum.	Termes pristinus.
Libellula platyptra.	

Lower Miocene.

Swiss Molasse.

Coleoptera.—26 Species.

	Species.		Species.
Carabidæ	... 6	Elateridæ	... 2
Dyticidæ	... 1	Helopidæ	... 2
Peltidœ	... 1	Lamiidæ	... 1
Hydrophilidæ	... 4	Chrysomelidæ	... 3
Melolonthidæ	... 1	Undetermined species	... 2
Buprestidæ	... 3		

Neuroptera.—2 Species.

	Species.		Species.
Libellulidæ	... 1	Phryganeidæ	... 1

Hymenoptera.—1 Species.

Vespidæ 1

Diptera.—1 Species.

Tipulidæ 1

Hemiptera.—3 Species.

	Species.		Species.
Pentatomidæ	... 2	Cicadellinæ	... 1

Total number of species from the Swiss Molasse :—33.

List of Fossil Insects from the Brown Coal of Rott, in Siebengeberge, enumerated by Professor Germar in the "Fauna Insectorum Europæ," 19, 1837 ("Insectorum Protogææ specimen," &c.), and by Dr. Giebel in "der Zeitschrift fur die gesammte Naturwissens

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chaft" (viii., 1856, s. 184), and in his "Fauna der Vorwelt" (1856).

COLEOPTERA.

[1]Platycerus sepultus.
Geotrupes vetustus.
,, proavus.
Trogosita tenebrioides.
,, emortua.
Silpha stratuum.
Escheria protogaea.
Dytiscus (larva).
Buprestis major.
Buprestis alutacea.
Chrysobothris xylographica.
Dicerca carbonum.
Tenebrio effossus.
Spondylis tertiaria.
Prionus umbrinus.
Molorchus antiquus.
Saperda lata.
Bruchus bituminosus.

HYMENOPTERA.

Formica lignitum.
Osmia dubia.

LEPIDOPTERA.

Ypsolophus insignis.

DIPTERA.

Helophilus primarius.
Anthracida xylotoma.
Bibio xylophilus.
Bibio lignarius
,, dubius.

ORTHOPTERA.

Decticus extinctus.

HEMIPTERA.

Alydus pristinus.
Belostomum Goldfussi.

Further list of insects from the Brown Coal of Rott, described by C. Von Heyden, in Meyer and Dunker's "Palæontographica," 1859-1861, vol. 8, pp. 1-15.

COLEOPTERA.

Hydrophilus fraternus.
Hydrous miserandus.
Byrrhus lucae.
Buprestis tradita.
Ancylochira redempta.
Dicerca Bronni.
Silicernius spectabilis.
Ptinus antiquus.
Tenebrio? senex.
Caryoborus ruinosus.
Tophoderes depontanus.
Hylotrupes senex.

HEMIPTERA.

Notonecta primæva.

HYMENOPTERA.

Bombus antiquus.
formica?

[1] The names given in this, and all the following lists, are in every case those used by the authors of the works from which the lists have been compiled, and no attempt has been made to correct any but clerical errors.

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LEPIDOPTERA.

[1] Vanessa vetula.

DIPTERA.

Chironomus antiquus.
Ctenophora Decheni.
Bibio deletus.
Bibio lignarius.
Bibiopsis volgeri.

Further list of insects from the Brown Coal of Rott, described by Dr. Hagen, in Meyer and Dunker's "Palæontographica," Vol. x (1863).

Calotermes rhenanus.
Leuctra antiqua.
Libellula cellulosa.
Ictinus fur.
Libellula ceres (nymphe).
Libellula cassandra (nymphe).
Aeschna Dido.
Agrion Thais.
„ Mysis.
„ Icarus.

Further list of *Diptera* from the Brown Coal of Rott, described by Carl von Heyden and Lucas von Heyden, in Meyer and Dunker's "Palæontographica," Vol. xiv (1865-6).

Bibio pannosus.
Protomyia abava.
„ collossea.
„ Winnertzi.
„ grossa.
„ luctuosa.
„ Proserpina.
„ macrocephala.
„ hypogaea.
„ exposititia.
„ stygia.
„ pinguis.
Protomyia veterana.
„ lapidaria.
„ grandaeva.
„ antenata.
„ luteola.
„ schineri.
„ elongata.
„ gracilenta.
„ Heeri
Plecia rhenana.
„ heroica.

Further list of *Diptera* from the Brown Coal of Rott, described by Lucas von Heyden in Dunker's "Palæontographica," Vol. xvii, pp. 237-272 (1867-1870).

Simula pasithea.
Sciara janassa.
„ defossa.
„ atavina.
„ Rottensis.
„ Winnertzii.
Cordyla vetusta.
„ subaptera.
„ antiqua.
„ reunda.
Cordyla limnoria.
Boletina philyra.
Chironomus bituminosus.
„ perditus.
„ dorminans.
„ decrepitus.
„ Palaemon.
Ceratopogon Alpheus.
Culex ceyx.
Erioptera Danaë.

[1] This is the only butterfly yet discovered in any formation of this period.

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Limnobia sturi.
Dilophus Krantzii.
Bibio janus.
„ mimas.
Asilus.?
Empis melia.
Pipiza venilia.
Syrphus euphemus.
Anthomyia Heymanni.
Dipterous larva of Stratiomys. ?

List of *Coleoptera* from the Brown Coal of Sieben geberge, described by Carl von Heyden and Lucas von Heyden, in Meyer and Dunker's "Palæontographica, Vol. xv (1866).

Harpalus abolitus.
Pelobius Cretzschmari.
Laccobius excitatus.
Ajabus reductus.
Hydrous Neptunus.
Philydrus morticinus.
Ochthebius Plutonis.
Tachyporus sepultus.
Philonthus bituminosus.
Sunius demersus.
Stenus scribai.
Oxyporus Vulcanus.
Anthophagus Giebeli.
Staphylinus (larva).
Seniaulus scaphioides.
Byrrhus exanimatus,
Aphodius Krantzi.
Anomala tumulata.
„ primigenia.
„ thetis.
Pentoclon Bellerophon.
Telephorus carbonarius.
„ exauctaratus.
„ caducus.
„ Brodiei.
Ptinus primordialis.
Xyletinites tinubicola.
Cis Krantzi.
Gonocephalum pristinum.
Microzoum veteratum.
Bolitophagus vetustus.
Platydema Geinitzi.
Myodites Meyeri.
Mylabris deflorata.
Choragus tertiarius.
Rhynchites Hageni.
„ orcinus.
Apion primordiale.
Brachymycterus curculionodi.
Sitones venustulus.
Hylobius antiquus.
Eurychirus induratus.
Larinus Bronni.
Rhinocyllus improlus.
Magdalinus protogenius.
„ Deucalionis.
Tychius mauderstjernai.
Acalles Icarus.
Ceutorrynchus funeratus.
Nanophyes japetus.
Sphenophorus proluviosus.
Lamia petrificata.
Labidostomis Pyrrha.
Lina sociata.
Plagiodera novata.
Coccinella Haagi.
„ Krantzi.
„ bituminosa.
„ fossilis.
Lasia primitiva.

List of insects from the Brown Coal of Sieblos, described by Carl von Heyden, in Meyer and Dunker's "Palæontographica, Vol. 5, pp. 115-120 (1858).

Buprestis Meyeri.
„ senecta.
Bruchus decrepitus.
Molytes Hassencampi.
Pissodes effossus.
Leptoscelis humata.
Lygæus fossitius.
Bracon macrostigma.

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Further list of insects from Sieblos, described by Carl von Heyden, in Meyer and Dunker's "Palæontographica," vol. 8, pp. 15-17 (1859).

Trachyderes bustiraptus.
Pachymerus antiquus.
Lygæus deprehensus.

In Meyer and Dunker's "Palæontographica," Vol. v. (1858), Dr. Hagen describes from the Brown Coal of Sieblos, two Neuroptera, viz. :—

Heterophlebia jucunda.
Lestes vicina.

List of insects from the Brown Coal of Salzhausen, described by Carl von Heyden, in Meyer and Dunker's "Palæontographica," Vol. iv (1856).

Dicerca Taschei.
Bibio antiquus.
Therera carbonum.

Further list of insects from the Brown Coal of Salzhausen, described by C. von Heyden and Lucas von Heyden, in Meyer and Dunker's "Palæontographica," Vol. xiv, 65-66. Taf. ix, fig. 13-22:—

Lebia amissa.
Helops wetteravicus.
Attagenus extinctus.
Lema tumulata.
Anthaxia carbonaria.
Clythra carbonaria.
„ deleta.
Pentatomia Bottgeri
„ primæva
Bibiopsis carbonum
Sphenoptera knopi.
Cynips pteromalus.

List of insects from the Brown Coal of the Nether Rhine and the Rhone, compiled from Meyer and Dunker's "Palæontographica," Vol. x (1861-1863) :—

COLEOPTERA.

Peltis costulata.
Uloma avia.
Onitis magus
Urodon priscus.
Anoplognathus rhenanus.
Cryptorhynchus renudus.
Perotis Hausmanni.
Dorcadion emeritum.
„ redita.
Oberea præmortua.
Dicerca Taschei.
Hesthesis immortua.
Ancylochira pristina.
Lina Wetteravica.
Agrilus Baueri.
„ populeti (Heer).
Limonius optalibis (Heer).
Cassida interemta.
Luciola extincta.
Coccinella antiqua.

ORTHOPTERA.

Blatta pauperata.

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HYMENOPTERA.

Osmia carbonum.
Anthophora effossa.
Apis domitans.

NEUROPTERA.

Corydalis?

LEPIDOPTERA.

Nepticula fossilis.

DIPTERA.

Bibio tertiarius.
Merodon Germari.
Culicites tertiarius.
Cecidomyia? dubia.
Fungicola.

List of insects from the Brown Coal of Stöschen :—

NEUROPTERA.

Ascalaphus proavus (Hagen).

HEMIPTERA.

Corrixa pullus (Heyden).
„ ? Micropus „
Typhlocyba carbonaria (Heyden).

List of insects from Corent, Menat, and St. Gerand le Puy, Auvergne, Central France, compiled from M. Oustalet's "Recherches sur les Insectes Fossiles," (pt. 1) :—

COLEOPTERA.

Eunectes antiquus.
Laccobius priscus.
Brachycerus Lecoquii.
Cleonus Arvernensis.
„ Fouilhouxii.
Hylobius deletus.
Anisorhynchus effossus.
Plinthus redivivus.
Bagous atavus.
Curculionites ovatus.

ORTHOPTERA.

One specimen not named.

NEUROPTERA.

Libellula minuscula.
Ascalaphus Edwardsii.
Phryganea Corentiana.
„ Gerandiana.

HYMENOPTERA.

Anthophorytes Gaudryi.

DIPTERA.

Penthetria Vaillantii.
Plecia major.
„ nigrescens.
„ pallida.
Bibio gigas.
„ Ungeri.
„ Ungeri (var marginatus).
Bibio macer.
„ alacris.
„ robustus.
„ Edwardsii.
„ cylindratus.
„ gracilis.
„ obsoletus.

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Bibio Lartetii.
Protomyia longa.
„ longipennis.
„ inflata.
„ lugens.
„ Joannis.
„ fusca.
„ Sauvagei.
Protomyia adusta.
„ globularis.
„ Blanchardi.
„ rubescens.
„ formicoides.
„ incerta.
„ Oustaleti.[1]
Stratiomys Heberti.

LEPIDOPTERA.

Noctuites incertissima.

UPPER EOCENE.

List of Genera of Fossil Insects from the Tertiary formations of Aix, in Provence (compiled from Mr. Curtis's paper in the "Edinburgh New Philosophical Journal" for 1829) :—

COLEOPTERA.

Harpalus.
Hydrobius.
Lathrobium. ?
Ptinus. ?
Cetonia.
Sitona.
Notaris. ?
Liparus.
Hypera.
Cassida.
Chrysomela.

HYMENOPTERA.

Tenthredo.
Ichneumon.
Formica.

LEPIDOPTERA.

Phalena? or one of the Noctuidæ. ?

HOMOPTERA.

Aphis.
Tettigonia.
Asirica ? or possibly Delphax.
Cixias, or Cercopis.

HEMIPTERA.

Miris.
Lygæus.
Corizus.
Cydnus.
Pentatoma. ?

DIPTERA.

Limnobia.
Gnoriste. ?
Mycetophila. ?
Bibio.
Empis.
etc.

List of genera of fossil Insects from Aix, in Provence, com-

[1] This species, *P. Oustaleti*, is not included in M. Oustalet's list. It is described by M. C. Brongniart in the "Bulletin de la Société Géologique de France," t. 4, 1876..

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piled from Bronn's "Lethæa Geognostica," and the Rev. F. W. Hope's paper in the 4th vol. of the Transactions of the "Entomological Society," London, pp. 250-255 :—

COLEOPTERA.

Harpalus.	Sitona.
Helobia.	Lixus.
Dyticus.	Cleonis.
Colymbetes.	Balaninus.
Hydrobius.	Cionus.
Staphylinus.	Brachycerus.
Lathrobium.	Rhynchænus.
Sisyphus.	Meleus.
Pachypus.	Hypera.
Geotrupes.	Naupactus.
Melolontha.	Rhinobatus.
Cetonia.	Dorytomus.
Buprestis.	Apate.
Elater.	Scolytus.
Atopa.	Hylurgus.
Ptinus.	Bostrichus.
Sepidium.	Trogosita.
Opatrum.	Ips.
Asida.	Callidium.
Bruchus.	Cassida.
Apion.	Chrysomela.
Rhynchites.	Coccinella.

ORTHOPTERA.

Forficula.	Acheta.
Gryllus.	Locustæ.
Gryllotalpa.	Tridactylus.

HYMENOPTERA.

Tenthredo.	Ophion.
Pimpla.	Polistes.
Ichneumon.	Vespa.
Cryptus.	Formica.
Agathis.	Chalcididæ.
Anomalon.	

NEUROPTERA.

Libellula.	Phryganea.
Agrion.	

HEMIPTERA.

Pentatoma.	Miris.
Coreus.	Syrtis.
Lygæus.	Nepa.

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Ranatra.
Cicada.
Delphax.
Cercopis.
Tingis.
Aradus.
Corizus.
Reduvius.
Ploiaria.
Gerris.
Notonecta.
Tettigonia.
Thrips.
Aphis.

LEPIDOPTERA.

Satyrus.
Zygæna.
Sesia.
Bombyx.

DIPTERA.

Mycetophila.
Rhingia.
Bibio.
Hirtæa.
Tabanus.
Sargus.
Ceratopogon.
Nephrotoma.
Limnobia.
Corethra.
Trichocera.
Platyura.
Sciara.
Scatops.
Penthetria.
Dilophus.
Anisopus.
Asilus.
Empis.
Nemestrina.
Xylophagus.
Oxycera.
Nemotelus.
Aphritis.
Tipula.

List of Fossil Coleoptera from Aix, compiled from M. Oustalet's "Recherches sur les Insectes Fossiles des Terrains Tertiaires de la France," 2nd part:—

CARABIDÆ.

Nebria Tisiphone.
Calosoma Agassiz.
Panagæus Dryadum.
Bembidium infernum.
Bembidium Saportanum.
Feronia minax.
Feronia provincialis.
Harpalus Nero.
„ deletus.
Stomis elegans.
Polystichus Hopei.

HYDROPHILIDÆ.

Hydrophilus antiquus.
Hydrophilopsis incerta.
Hydrobius obsoletus.
Laccobius vetustus.

STAPHYLINIDÆ.

Stenus prodromus.
„ Gypsi.
Achenium ingens.
Erinnys elongata.
„ deleta.
Lithocaris varicolor.
Xantholinus Westwoodianus.
Staphylinus calvus.
„ Germarii.
„ provincialis.
Staphylinus aquisextanus.
„ atavus.

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Staphylinus prodromus.
„ priscus.
Philonthus Bojeri.
„ Marcelli.
Quedius Reynesii.
„ Lortetii.
Hygronoma deleta.

SCYDMENIDÆ.
Scydmænus Heerii.

LATRIDIIDÆ.
Corticaria melanophthalma.

MYCETOPHAGIDÆ.
Triphyllus Heerii.

SCARABIDÆ.
Onthophagus luteus.
Geotrupes atavus.

EUCNEMIDÆ.
One species unnamed.

ANTHICIDÆ.
Anthichus melancholicus.

CURCULIONIDÆ.
Hipporhinus Heerii.
„ Schaumii.
„ Reynesii.
Brachyderes longipes.
„ aquisextanus.
Sitones margarum.
Cleonus leucosiæ.
„ Marcelli.
„ asperulus.
„ inflexus.
„ sexsulcatus.
„ pygmæus.
Tanysphyrus deletus.
Hylobius morosus.
„ carbo.
Hylobius Solieri.
Plinthus Heerii.
Phytonomus firmus.
„ annosus.
Coniatus minusculus.
Erirhinus Chantrei.
Hydronomus nasutus.
Balaninus Barthelemyi.
Sybines melancholicus.
Cryptorhynchus gypsi.
Cæliodes primigenius.
Cossonus Marionii.
Curculionites parvulus.
„ lividus.
„ exiguus.

SCOLYTIDÆ.
Hylesinus facilis.

CERAMBYCIDÆ.
Clytus leporinus.

CHRYSOMELIDÆ.
Crioceris margarum.
Chrysomela Lyelliana.
„ matrona.
„ Matheroni.
Chrysomela debilis.
Gonioctena Curtisii.
Cassida Blancheti.

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List of Fossil Lepidoptera (Rhopalocera) from Aix, compiled from Scudder's "Fossil Butterflies," in the Memoirs of the American Association for the Advancement of Science:—

Neorinopis sepulta.	Thaites ruminiana.
Lethites Reynesii.	Pamphilites abdita.
Coliates Proserpina.	

Middle Eocene.

List of species from Monte Bolca, near Verona, in Italy, compiled from Massalongo's "Studii Paleontologici":—

Coleoptera.

Ancylochira deleta.	Perotis lævigata.

Orthoptera.

Forficula Bolcensis.

Neuroptera.

Cordulia Scheuchzeri.	Termes peccanae

Diptera.

Dipterites Angelinii.	Bibio Sereri.

American Strata.

Recent or Post Tertiary.

[1] List of Fossil Coleoptera from Cave deposits (belonging to the Post Pliocene period), at Port Kennedy, Pennsylvania, described by Dr. G. H. Horn in the "Transactions of the American Entomological Society," Vol. v., pp. 241-245 (Sept., 1876):—

Coleoptera.

Cychrus Wheatleyi.	Dicaelus abutaceus.
Pterostichus (2 species not named)	Choridium (?) ebuinum.
Cymnidis aurora.	Phanæus antiquus.
Chlænius punctulatus.	Aphodius precursor.

Carabidæ discovered in the Interglacial Deposits of Scarborough Heights, near Toronto, Canada (described by Mr. S. H. Scudder, in the "Bulletin of the United States Geological and Geographical Survey" (Vol. iii., No. 4, art. xxx.):—

Loricera glacialis.	Loxandrus gelidus.

[1] I have not myself seen the volume of the Transactions of the American Entomological Society, in which these species are described, but am indebted to Mr. R. M'Lachlan, F.R.S., for an extract from it, and for the list of species here given.

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Tertiary.

List of some of the Fossil Insects, from the Rocky Mountain Tertiaries, (Tertiary Beds of White River), obtained by Professor William Denton, and described by S. H. Scudder. (Compiled from the "Bulletin of the Geological and Geographical Survey of the Territories," Vol. ii., No. 1):—

Coleoptera.

Bembidium exoletum.
Laccophilus ?
Philhydrus primævus.
Staphylinites obsoletum.
Gyrophæna saxicola.
Leistotrophus patriarchicus.
Lathrobium abscessum.
Oxytelus pristinus.
Antherophagus priscus.
Phenolia incapax.
Chrysobothris Haydeni.
Epiphanis deletus.
Corymbites velatus.
Oxygonus mortuus.
Chauliognathus pristinus.
Sitodrepa defuncta.
Spermophagus vivificatus.
Bruchus anilis.
Oryctoscirtetes protogœum.
Trypodendron impressus.
Sitones grandœvus.
Otiorhynchus perditus.
Entimus primordialis.
Eudiagogus saxatilis.
" examinis.
" effossus.
Hylobius provectus.
Anthonomus defossus.
Cryptorhynchus annosus.
Eurhinus occultus.
Brachytarsus pristinus.

Orthoptera.

Homœogamia ventriosus.
Labidura Tertiaria.

List of the remainder of the Insects obtained by Professor William Denton, in Tertiary Beds of White River, and described by Mr. S. H. Scudder, in the "Bulletin of the United States Geological and Geographical Survey" (Vol. iii., No. 4, Art. xxix.):—

Hymenoptera.

Formicidæ.

Camponotus vetus.
Liometopum pingue.

Ichneumonidæ.

Ichneumon petrinus.

Diptera.

Culicidæ.

Culex proavitus.
Corethra exita.

Chironomidæ.

Chironomus depletus.
Chironomus patens.

Cecidomyidæ.

Lasioptera recessa.
Lithomyza condita.

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Tipulidæ.

Dicranomyia stigmosa.
„ primitiva.
„ rostrata.
Spiladomyia simplex.
Pronophlebia rediviva.
Cyttaromyia fenestrata.
Tipula decrepita.
„ tecta.

Mycetophilidæ.

Mycetophila occultata.
Sackenia arcuata.
Gnoriste dentoni.

Cyrtidæ.

Acrocera hirsuta.

Syrphidæ.

Eristalis lapideus.

Muscidæ.

Musca ascarides.
„ bibosa.
Musca hydropica.
„ vinculata.

Helomyzidæ.

Heteromyza detecta.

[1] COLEOPTERA.

Carabidæ.

Bembidium exoletum.

Dyticidæ.

Laccophilus (allied to L. Maculosus).

Staphylindæ.

Gyrophœna saxicola.
Leistotrophus patriarchicus.
Oxytelus pristinus.

Elateridæ.

Epiphanis deletus.
Oxygonus mortuus.

Bruchidæ.

Bruchus anilis.

Curculionidæ.

Entimus primordialis.

HEMIPTERA.

Fulgoridæ.

Aphana atava.
Delphax senilis.

Tettigonidæ.

Tettigonia obtecta.
Bythoscopus lapidescens.

Lygæidæ.

Pachymerus petrensis.

Physopoda.

Melanothrips extincta.
Lithadothrips vetusta.
Palœothrips fossilis.

NEUROPTERA.

Phryganidæ.

Phryganea operta.

[1] These *Coleoptera* were included in the preceding list.

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List of Fossil Insects obtained by Mr. George M. Dawson, from the Tertiary Beds at Quesnel, British Columbia, and described by Mr. S. H. Scudder. (Compiled from the "Report of Progress," 1875-1876—Geological Survey of Canada) :—

COLEOPTERA.

Nitidulidæ.

Prometopia depilis.

NEUROPTERA.

Odonata.

One species allied to Diplax minuscula.

HYMENOPTERA.

Formicidæ.

Formica arcana.
Aphœnogaster longœva.
Hypoclinia obliterata.

Ichneumonidæ.

Pimpla saxea.
Pimpla decessa.
Pimpla senecta.

Braconidæ.

Calyptites antediluvianum.

DIPTERA.

Chironomidæ.

Several species referable to this family.

Mycetophylidæ.

Boletina sepulta
Brachypeza procera.
Brachypeza abita.
Trichonta Dawsoni.

Dolichopodidæ.

A single specimen referable to this family not named.

Anthomyidæ.

Anthomyia inanimata.
Anthomyia Burgessi.

Helomyzidæ.

Heteromyza senilis.

Sciomyzidæ.

Sciomyza revelata.

Ortalidæ.

Lithortalis picta.

Lonchaeidæ.

Lonchæa senescens.
Palloptera morticina.

HEMIPTERA.

Aphidæ.

Lachnus petrorum.

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Herrn Dr. Hagen
JUL 31 1915
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Von Verfa

Three Papers on Fossil Insects, and the British and Foreig
Formations in which Insect Remains have been detected.

No. 2.

THE INSECT FAUNA

OF THE

SECONDARY OR MESOZOIC PERIO

(Read before the Geologists' Association on the 4th January, 1878).

H. Hagen

BY

H. GOSS, F.L.S.

Reprinted from "PROCEEDINGS OF THE GEOLOGISTS' ASSOCIATION," Vol. VI
1879. No. 3. p 116-150

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THE INSECT FAUNA

OF THE

SECONDARY OR MESOZOIC PERIOD,

AND THE

BRITISH AND FOREIGN FORMATIONS OF THAT PERIOD IN WHICH INSECT REMAINS HAVE BEEN DETECTED.

By HERBERT GOSS, F.L.S., F.G.S., F.Z.S.,

Member of the Entomological Societies of France and London.

Introduction.

It will be unnecessary for me to make any preliminary observations in this Paper as to the importance of an acquaintance with Fossil Entomology, or as to the valuable conclusions bearing upon the geological conditions of the Earth in former ages, which may be arrived at from a study of insect remains; such remarks as I had to offer on this subject having already been made in the introductory portion of my first Paper.

In the Secondary Rocks of this country fossil insects have been found far more frequently than in those of either the Recent or Tertiary ages, and in some few localities these fossils are, comparatively speaking, abundant.

For such a knowledge as we have of the Insect Fauna of this country during the Secondary Period, we are indebted principally to the Rev. P. B. Brodie, F.G.S., who, as I have before remarked,[1] is the author of the *only*[2] *book* on fossil insects, either of this or any other period, which has been published in this country. In the determination of a large number of the insects described and figured in this book, as well as for some important introductory

[1] See Proc. Geol. Assoc., Vol. v., p. 285.

[2] "A History of the Fossil Insects in the Secondary Rocks of England." London, 1845: (Van Voorst.)

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observations therein, Mr. Brodie had the advantage of the assistance of Professor Westwood[1] of Oxford.

We are indebted to Mr. Brodie not only for the interesting and valuable work just mentioned, but also for numerous papers on fossil insects which have from time to time appeared in the[2] "Quarterly Journal of the Geological Society," "The Annals and Magazine of Natural History," "The Proceedings of the Warwickshire Naturalists' Field Club," &c.

Amongst the names of other contributors to our knowledge of fossil *Insecta* obtained from British strata of this Period, I must mention those of Mr. W. R. Binfield,[3] Mr. H. Binfield, Prof. Morris,[4] F.G.S., Dr. Mantell,[5] F.R.S., Prof. Edward Forbes, F.R.S., Mr. W. R. Brodie,[6] Mr. C. Willcox,[6] the Rev. O. Fisher, F.G.S.,[6] Captain Woodley,[6] the Rev. Dr. Buckland, F.R.S.,[7] Mr. H. E. Strickland, F.G.S., Mr. A. G. Butler, F.L.S.,[8] Mr. S. H. Scudder,[9] and Mr. E. T. Higgins.

The British formations of this Period in which remains of insects have been found most plentifully, are the upper series of the Upper Oolite (*i.e.*, the Purbecks), and the Lias and Rhætics. The only other formations of this age in which they appear to have been yet discovered in the United Kingdom, are the Hastings Sands, and some other subordinate members of the Lower Cretaceous or Neocomian system, the Kimmeridge Clay, Oxford Clay (?), Forest Marble, Great Oolite, and the Stonesfield Slate.

Although the presence of insects in marine formations may be accounted for by supposing them to have been driven by the wind into the sea, when in its neighbourhood, or when attempting to cross it, yet, as a rule, where their remains have been de-

[1] Professor Westwood also contributed an important paper on Fossil Entomology, in the Quart. Journ Geol. Soc., for 1854. Vol. x., pp. 378-396.

[2] See "Athenæum," January, 1843. "Proceedings Geol. Soc.," Vol. iii., pp. 134, 135, and pp. 780-782. "The Annals and Mag. of Nat. Hist.," 1843, Vol. ii., p. 480. "Quart. Journ. Geol. Soc.," 1846, pp. 14-16. "Quart. Journ. Geol. Soc.," 1847, pp. 53, 54; Vol. v., pp. 31-35; Vol. ix., 1853 (pp. 51, 52); and Vol. x.,, 1854 (pp. 475-482). "The 35th Annual Report of the Warwickshire Natural History Society" (1871); and the "Proceedings of the Warwickshire Naturalists' and Archæologists' Field Club," 1874, 1877, and 1878.

[3] "Quart. Jour. Geol. Soc." Vol. x., p. 171.

[4] "A Catalogue of British Fossils." London, 1854.

[5] "Medals of Creation," Vol. ii., p. 555; and "Quart. Journ. Geol. Soc.," Vol. ii., p. 96.

[6] "Quart. Journ. Geol. Soc.," Vol. x., antea cit.

[7] "Bridgwater Treatise," Vol. ii., p. 78; and "Phil. Mag.," 1844.

[8] "Lepidoptera Exotica," pp. 126-8; and "Geol. Mag.," Vol. x.

[9] "Fossil Butterflies," pp. 90-95 of the "Memoirs of the American Association for the Advancement of Science," No. 1, Salem, Mass., 1875.

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tected in abundance in such formations, they may generally be considered as satisfactory evidence that land was not far distant at the time they were embedded; and the abundance of other terrestrial remains, usually accompanying these fossils in such formations, leaves but little doubt upon the subject.

One notable exception to this rule is the Continental formation known as the Solenhofen Slate of Bavaria, in which insect remains are said to be mixed up, almost exclusively, with the *débris* of *marine* animals and plants.

Before proceeding to notice in detail the various formations of the Period from which fossil insects have been obtained, I think it may be interesting to call attention to the striking difference in the state of preservation of the insects from British strata of this period, with that of those from one of the most important of the Continental formations, *i.e.*, the Solenhofen Slate.

On the subject of the deposition of the Solenhofen insects, I will quote Dr. Hagen,[1] who observes—"On comparing the insects of Solenhofen and Eichstadt with those of England, there appears, in the first place, a difference which may possibly admit of interesting inferences; the insects of the Bavarian strata are almost universally preserved entire; wings, legs, head and antennæ are in their proper places; most of the *Libellulæ* have their wings expanded. He who has noticed on the sandy shores of the Baltic how depositions of insects are now taking place, will admit that the insects of the Solenhofen strata were already dead when deposited."

"The insects would be, as now, driven by the wind into the sea, thrown on the shore dead or dying, and there gradually covered with sand by the rippling waves. That this process took place gradually and slowly in the Solenhofen strata is evident also from another circumstance; for we frequently find the cavities of insects—the head, thorax and body—filled up with regular crystals of calcareous spar. Hence, the pressure of the stratum overlying the insects must have been very slight, when such delicate parts as the abdominal segments of a dragon fly could oppose resistance for a sufficient length of time to admit of the formation of crystals. Naturally there do occur, here and there, in the Solenhofen strata, impressions of insects obtained in a different way, which admit of the idea of a very heavy pressure from the superincumbent strata; yet these specimens are scarce, and form only a small proportion of the entire number."

[1] See a paper read by Dr. Hagen before the Geological Section of the Brit. Assoc. at Manchester, Sept., 1861; and see the "Entomologists' Annual," for 1862, pp. 1-10.

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Now the state of preservation of fossil insects obtained from British strata of this period is, as Dr. Hagen goes on to observe, in strong contrast to that of the Solenhofen insects. The fossil insects discovered in British formations of this age are seldom entire, and their remains generally consist of single wings, or parts of wings.

The imperfect condition of the English fossils may be accounted for on the supposition that their deposition did not take place in the manner of the Solenhofen insects, but only after they had for a long time been tossed about by storms or other commotions, or remained for years soddening in water.

On the Continent of Europe, so far as present discoveries enable us to judge, insect remains do not, as a rule, appear to have been found in the Secondary Rocks in any abundance; but to this rule the Solenhofen Slate of Bavaria, and the Lias of Schambelen in the Swiss Alps, form a striking exception.

For a knowledge of the fossil Insecta of the Solenhofen Slate, we are indebted chiefly to Professor Germar,[1] Count Münster,[2] Dr. Hagen,[3] and Herr H. Weyenbergh, jun.;[4] and to Professor Oswald Heer[5] we owe our knowledge of those from the Lias of the Swiss Alps.

Amongst the names of other students of the fossil Insecta of the Continental European formations of this period, may be mentioned — Schröter,[6] Schmiedel,[7] Esper,[8] Schlotheim,[9] Van

[1] "Ueber die Versteinerten Insekten des Juraschiefers von Solenhofen," Isis iv., pp., 421-424, 1837; and "Die Versteinerten Insekten Solenhofens," Acta. Akad. Leop. Car., t. 19, pp 187-222, 1839.

[2] "Beiträge zu. Petref.," t. 5, 1841.

[3] See "Enumération des Odonates fossiles d'Europe," at pp. 356-364 of "Revue des Odonates," by E. de Selys-Longchamps. Liège, 1850. The "Entomologists' Annual," 1862; and "Ueber die Neuroptern aus dem Lithographischen Schiefers in Bayern," "Palæontographica," Vol. x., pp. 96-145, 1861-1863; also "Die Neuroptern des Lithographischen Schiefers in Bayern;" "Palæontographica," Vol. xv., p. 57-96, 1865-1868.

[4] "Sur les insectes fossiles du calcaire lithographique de la Bavière, qui se trouvent au Musée Teyler;" "Archives du Musée Teyler," Vol. ii., pp. 247-294, Harlem, 1869; and Vol. iii., pp. 234-240.

[5] See "Die Urwelt der Schweiz" (1865), and a translation of the same into French, by M. Demole; also an English translation by W. S. Dallas, F.L.S., published under the title of "The Primæval World of Switzerland," and edited by J. Heywood, F.R.S. London, 1876.

[6] "Real und Verbal Lexicon," II., s. 93; III., s. 72, 1779; and "Neue Litteratur und Beitr. zur Kenntniss der Naturwissench.," T. 1, p. 410, 1784.

[7] "Vorstellung einiger Merkwürdiger Versteinerungen," Nürnberg, 1781.

[8] "De Animalibus Oviparis," &c., 1783.

[9] "Petrefactenk," p. 42, 1820.

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der Linden,[1] Köhler,[2] von Buch,[3] von Meyer,[4] Geinitz,[5] Marcel de Serres,[6] Bronn,[7] Pictet,[8] C. von Heyden,[9] Giebel,[10] Ch. Brongniart,[11] and Winkler.[12]

I will now briefly review, in the descending order of geological succession, the various formations of this period in which insect remains have been detected, and the orders, families, genera and species, to which such remains have been referred.

GREAT BRITAIN.

LOWER CRETACEOUS OR NEOCOMIAN.

In the[13] Lower Cretaceous or Neocomian rocks remains of insects are extremely rare, and confined, so far as present discoveries enable us to judge, to the lowest members (Weald Clays and Hastings Sands) of the series.

The first discovered fossil insects from the Wealden were found in the neighbourhood of Hastings, by Messrs. W. R. and H. Binfield. They consisted of a few minute elytra of *Coleoptera*, and fragments of *Neuropterous* wings, and were obtained in the courses of ironstone exposed at low water-mark, at a place called the "Govers,"[14] near St. Leonards-on-Sea. Above the course of the ironstone, in a bed of dark-coloured shale, many elytra of *Coleoptera* were found, as well as traces of wings of *Coleoptera*, *Neuroptera* and *Diptera*.

A few fragments of *Coleopterous* elytra have also been discovered

[1] "Mem. Acad. Brux.," Vol. iv., p. 247, 1826.
[2] Leonhard's "Zeitschr. für Min.," &c., T. 2, p. 231, 1826.
[3] "Abhand. Berliner Akad.," 1837.
[4] See Erichson und Grüber's "Encyclopædie," Sec. 2, xviii., p. 537, 1840; art. "Fossile Insekten aus dem lithographischen Schiefer."
[5] "Characteristik der Kreidegebirge," p. 13; and "Grundriss der Versteinerungskunde," p. 187, 1846.
[6] "Géognosie des Terrains Tertiaires," &c., Livre IV., sec. 3, p. 244, 1829.
[7] "Lethea Geognostica," Vol. i., p. 210, 1835-1837.
[8] "Traité élémentaire de Paléontologie," Vol. iv., 1846.
[9] "Palæontographica," Vol. i., p. 99, 1851.
[10] "Fauna der Vorwelt," 1856; and "Zur Fauna des lithographischen Schiefers von Solenhofen," T. 9, pp. 373-388, 1857.
[11] "Annales de la Soc. Entomologique de France," v^e^ serie p. 217 (1876).
[12] "Catalogue Systématique de la Collection Paléontologique" (Musée Teyler), 1876.
[13] In this paper I have followed the arrangement of Sir Charles Lyell.
[14] See a paper "On the occurrence of Fossil Insects in the Wealden Strata of the Sussex Coast," by W. R. and H. Binfield, communicated by Professor Morris, in the "Quart. Journ. Geol. Soc.," Vol. x., p. 171.

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in the Wealden Marlstone, between Tonbridge and Maidstone, and are alluded to by Dr. Mantell.[1]

In the "Quarterly Journal of the Geological Society"[2] for 1854, Professor Westwood alludes to the discovery[3] by the late Edward Forbes, of some traces of fossil insects in the Hastings Series of the Isle of Wight, and of a few doubtful specimens by Mr. W. R. Brodie, in the Wealden of Punfield Bay, Swanage, Dorsetshire.

UPPER OOLITE.

Purbecks.

In the Rev. P. B. Brodie's interesting work on "The Fossil Insects of the Secondary Rocks of England," the Purbecks are referred to the Wealden formation; but modern Geologists are of opinion that, in consequence of the organic remains discovered therein, the Purbeck series has a close affinity to the Oolitic group, and that it should therefore be considered the newest or uppermost member of that formation, instead of the oldest or lowest member of the Wealden.

The Purbeck Beds are divided by Professor Edward Forbes into the Upper, Middle,[4] and Lower. It is from the middle and lower divisions that insect remains have been obtained in the greatest numbers. The great majority of these fossils were discovered by the Rev. P. B. Brodie, the Rev. Osmund Fisher, Mr. W. R. Brodie, Captain Woodley and Mr. C. Willcox.

In the "Quarterly Journal of the Geological Society"[5] for 1846, the Rev. P. B. Brodie recorded the discovery of a few imperfect remains of insects in Purbeck (?) strata in the neighbourhood of Swindon, Wilts.

A large collection of insect remains[6] was obtained by Mr P. B. Brodie from the Middle Purbecks of Durl'ston Bay, Dorsetshire. These remains included elytra, bodies and wings of *Coleoptera*, *Orthoptera* and *Diptera*, and portions of the wings of *Neuropterous* insects.

1 See "Quart. Journ. Geol. Soc.," No. 34, Vol. ii., p. 96.
2 Vol. x., p. 378-396.
3 "Quart. Journ. Geol. Soc.," 1853.
4 See a paper on "The Dorsetshire Purbecks," by Professor E. Forbes, F.R.S., Brit. Assoc. Edinb., 1850.
5 "Quart. Journ. Geol. Soc.," 1846, Vol. iii., pp. 53, 54.
6 "See Quart. Journ. Geol. Soc.," 1854, pp. 378, 396.

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A large collection of fossil insects was also obtained by Mr. Willcox from the Purbeck beds near Swanage; it consisted of some 60 slabs, each containing a number of remains. Professor Westwood says that the fossils obtained by Mr. Willcox included a very extensive series of elytra of *Coleoptera* (including *Buprestidæ* and *Harpalidæ*), also fragments of the wings of *Libellulidæ*, *Blattidæ*, *Tipulidæ*, &c.

Numerous fossil insects were obtained by the Rev. Osmund Fisher from the Ridgway Quarries (Lower Purbecks), near Dorchester.

The largest collection of insect remains from the Lower Purbecks was made by the Rev. P. B. Brodie. "It consisted," says Professor Westwood, "of 350 small slabs of stone of various sizes. Upon many of them only a single fragment of an insect occurs; but upon a considerable number the remains are very numerous, the fragments being crowded together, and often lying one upon another." These remains included quantities of elytra of *Coleoptera*, and also wings and wing covers of *Neuroptera* and *Orthoptera*, and two wings which were, for some time, supposed to be *Lepidopterous*.

The very fragmentary nature of these remains rendered the identification of the majority of them a matter of impossibility; but from Professor Westwood's paper in the "Quarterly Journal of the Geological Society,"[1] for 1854, and from the list of species in Dr. Giebel's "Fauna der Vorwelt,"[2] some 86 species seem to have been determined, viz :—

Coleoptera	45 species.	Hymenoptera ?...	2 species.
Orthoptera... ...	12 „	(very doubtful)	
Neuroptera ...	10 „	(supposed) Lepidoptera ?[3] ...	2 „
Hemiptera	11 „		
Diptera	4 „		

On the subject of these supposed remains of *Lepidoptera*, Mr. Scudder[4] observes, "I have not been able to find, even with Mr. Brodie's help, the first specimen referred to; but an examination of the original of the latter, proved that while it is unquestionably an insect, it cannot be referred to the *Lepidoptera*. As the figure of the first species clearly resembles, in this particular, the one I

[1] Vol. x., pp. 378-396.
[2] "Fauna der Vorwelt (Insecten und Spinnen"), Vol. ii., pp. 187 and 393-426.
[3] "Quart. Journ. Geol. Soc.," 1854, above cited. (See note 1, p. 124.)
[4] "Fossil Butterflies" pp. 88 and 89.

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have seen, I am forced to the conclusion that neither of these wings is *Lepidopterous*."

The Purbeck strata in the Vale of Wardour in Wiltshire, consist, according to Mr. Brodie, of a series of clays, white limestones, grits, sandstones, coarse blue limestones, and fine white slaty limestone. In this last-mentioned limestone, insect remains have been detected in such abundance that it has been called—both here and in Dorsetshire—the "Insect Limestone." It was chiefly from this Limestone in the Vale of Wardour in Wilts, and the Vale of Aylesbury in Bucks, that the large collections of fossil insects were obtained which furnished materials for Brodie's "History of the Fossil Insects in the Secondary Rocks of England." Out of some 240 specimens, or parts of specimens, from these formations, 74[1] were figured by Professor Westwood in the work last mentioned. The very fragmentary and imperfect condition of a great quantity of the insect remains discovered in these formations rendered it impossible, even for so experienced an Entomologist as Mr. Westwood, to determine, in many cases, the species, or even the Orders to which they belonged.

A great many have, however, been identified, and, according to the lists given by Mr. Brodie, in his "History of the Fossil Insects in the Secondary Rocks," and by Dr. Giebel, in his "Fauna der Vorwelt," the *Coleoptera*, *Orthoptera*, *Neuroptera*, *Hemiptera*, and *Diptera* are represented by some 65 species, distributed as follows, viz.:—

Coleoptera ...	... 18 species.	Hemiptera ...	... 14 species.
Orthoptera ...	... 10 „	Diptera ...	... 13 „
Neuroptera...	... 10 „		65

The *Coleoptera* appear to have been very well represented, and to have included *Buprestidæ*, *Carabidæ*, *Curculionidæ*, *Chrysomelidæ*, *Elateridæ*, *Cantharidæ*, *Tenebrionidæ*, &c. Mr. Westwood also detected amongst the insect remains from this formation, *Cercopidæ*, *Cimicidæ*, *Tipulidæ*, *Blattidæ*, *Aphidæ* and *Gryllidæ*.

On the subject of the remains from the Dorsetshire Purbecks, Professor Westwood observes, "With the exception of the Dragon flies, of which there are as many as 34 fragments of single wings

[1] See "Introductory Observations," by Professor Westwood, to Brodie's "History of the Fossil Insects in the Secondary Rocks of England.;" and the "Quart. Journ. Geol. Soc.," for 1854.

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(from which, however, it is impossible to affirm either a moderate or tropical climate), and of a large ant (?) wing[1], it is worthy of remark that the whole of these remains, not fewer than 700 or 800, are those of minute insects, not more than a fourth or a third of an inch in length." Further on, in the same paper, he says, "If we take into consideration the small and even minute size of the great majority of the insects, and, indeed, of the whole of the *Coleoptera* which have been passed under review, the idea that we have before us the wreck of an Insect Fauna of a temperate region is at once raised; for, although it would be rash to assert that a mass of remains of the existing tropical insects might not be accumulated in which a large quantity of minute beetles and flies would not be present, yet I cannot conceive any process, either arising from currents of water or chemical dissolution of insect matter, which would carry off or destroy the many gigantic forms of insect life always occurring in the tropics. The fossils before us show abundant evidence of the presence of numbers of lignivorous species, such as the *Elateridæ* and *Buprestidæ*, but we nowhere find amongst them traces of the great *Lamellicorn* and *Longicorn* Beetles. Herbivorous insects also occur in considerable numbers, but we do not meet with the gigantic Grasshoppers and Locusts of tropical climates."

Entomologists[2] are aware that sudden inundations, or the rapid rising of rivers, are sure to bring with them vast quantities of insects which are carried away by currents in great numbers, and congregated together in masses.

It appears that, with a few exceptions, there is a very general conformity between the insects from the Dorsetshire Purbecks and those of Wilts and Bucks. There would, however, appear to have been a great difference in the manner of deposition of the strata of the two districts, as evidenced by the remarkable contrast presented by *the state of preservation* of the insects of the Wiltshire Purbecks,

[1] Prof. Rupert Jones, F.R.S., has informed me that the ant wing was not obtained from Purbeck strata. See his letter at p. 348, Vol. vii., of the "Geol. Mag.," July, 1870.

[2] In a letter dated the 20th July, 1878, Mr. Alfred Russell Wallace remarks that "the quantity of insects carried down and drowned during floods is enormous. About 30 years ago the late T. V. Wollaston gave an account in the 'Zoologist' of his entomologising in South Wales, among the *débris* left by a flood. The *débris* literally swarmed with insects, especially beetles, and he obtained an enormous haul, including many excessively rare species."

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and that of those of the Dorset Purbecks. In the *former* numbers of specimens are in a fair state of preservation, while in the *latter*, the remains consist, almost always, of fragments of wings, elytra or bodies.

Kimmeridge Clay.

Mr. P. B. Brodie [1] states that at Ringstead, in Dorsetshire, this Clay is traversed by a bed of sandy laminated stone, about two feet thick, and this is succeeded by dark-coloured shale and clay, containing large blocks of Septaria, in one of which he discovered a striated elytron of a small Beetle.

With this exception, I have been unable to find any record of the discovery of insect remains from this part of the Upper Oolite.

MIDDLE OOLITE.

Oxford Clay.

The only trace of an insect from this division of the Oolite was found by Mr. J. C. Pearce, near Christian Malford. Professor Westwood thought that this fossil might possibly be that of a larva of a *Libellula*.[2]

LOWER OOLITE.

Forest Marble.

The only record of the discovery of fossil insects from this part of the Oolite is made by Mr. P. B. Brodie, who states that in some of the quarries in this series at Farleigh, near Bath, he found a few elytra of small Beetles.

Great Oolite.

Elytra of *Coleoptera*[3] are recorded from the Great Oolite in the eastern Moorlands of Yorkshire. The discovery of these remains is also alluded to by Dr. Mantell[4] in the "Medals of Creation."

[1] See the "Quart. Journ. Geol. Soc." Vol. ix., p. 51. 1853, and a paper "On the Distribution and Correlation of Fossil Insects," by the Rev. P. B. Brodie, Warwick, 1874.

[2] Figured by Brodie in his "Fossil Insects," plate iv., fig. 13.

[3] See Brodie's paper "On the Distribution and Correlation of Fossil Insects," antea cit.

[4] See the "Medals of Creation," Vol. ii., p. 555. See also the "Bridgwater Treatise," Vol. ii., p. 78; also "Loudon's Mag. of Nat. Hist.," Vol. iii., p. 361. In a note at page 379 of the "Quart. Journ. Geol. Soc." for 1854, reference is made by Professor Westwood to a fossil insect having been discovered by Professor Morris in the Great Oolite of Lincolnshire.

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Stonesfield Slate.

The remains of insects in this formation appear to be almost confined to a few families of *Coleoptera*, and they are generally in a very fragmentary condition, and consequently most difficult to determine.

Dr. Buckland has described the wing of a large *Neuropterous*[1] insect from the Stonesfield Slate, which has been named *Hemerobioides giganteus*,[2] and in the list at the end of Mr. Brodie's paper "On the Distribution and Correlation of Fossil Insects" another specimen of a *Neuropterous* insect is enumerated (*Libellula Westwoodi*), besides two large wings, referred to the *Libellulidæ* which were found at Eyeford on the Cotswolds, by Mr. Brodie.

The remains of *Coleoptera* from this Slate have been referred by Brodie and Westwood to some seven families, including *Buprestidæ*, *Curculionidæ*, *Coccinellidæ*, *Prioniidæ*, &c.

By far the most interesting fossil insect from the Stonesfield Slate is the wing of a large species which Professor Westwood, Mr. Bates, and Mr. Butler believe to be *Lepidopterous*. In the[3] "Proceedings of the Entomological Society of London" for 1872,[4] we find the following notice of its exhibition at a meeting of that Society. "Mr Butler exhibited a remarkably perfect impression of the wing of a fossil butterfly, in the Stonesfield Slate. It appeared to be most nearly allied to the now existing South American genus, *Calligo*." Mr. Butler[5] subsequently named this fossil *Palæontina Oolitica*, and described and figured it in his "Lepidoptera Exotica." He observes—"Though a British insect, this species belongs to a group so completely tropical, that I do not hesitate to describe and figure it in the present work; its nearest allies are the genera *Calligo*, *Dasyophthalma*, and *Brassolis*, all three essentially tropical American genera. *P. Oolitica* is especially interesting as being the oldest fossil butterfly yet discovered; the most ancient previously known to Science (*Neorinopis sepulta*)

[1] See "Geol. Proc.," Vol ii., p. 688, and Mantell's "Medals of Creation," Vol. ii., p. 552.

[2] Dr. Hagen states that this insect should be referred to *Apochrysa*

[3] Page xxxvi., 1872.

[4] See Sir Sidney Smith Saunders's observations on this fossil in his Anniversary Address to the Entomological Society (when President of that Society) in January, 1874.

[5] See "Lepidoptera Exotica" pp. 126-8, by A. G. Butler. It was also described and figured in the "Geological Magazine," Vol. x.

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having been found in the[1] Cretaceous series (white sandstone of Aix la Chapelle) whilst the bulk of the known species are from the Lower Miocene beds of Croatia; it is also interesting as belonging to the highest family of butterflies, and to a sub-family intermediate in character between two others, viz., the *Satyrinæ* and *Nymphalinæ*, whilst the more recently discovered fossils are referable, with one exception, to the two latter groups. The nervures appear to have been impregnated with iron, which will partly account for their well defined condition."

Mr. Scudder, who states that he carefully examined the original fossil, considers Mr. Butler to be in error in referring this wing to a *Lepidopterous* insect, and is of opinion that it should be considered *Homopterous*, and allied to *Cicada*.

Mr. Butler has himself directed my attention to the neuration of this wing, as figured, and also to that of some of the *Cicadæ* in the British Museum Collection, and from a comparison of figures of the wing with these insects I am inclined to agree with Mr. Butler, who in his view is supported by Professor Westwood and Mr. Bates. At the same time, as we have no evidence of the existence of true flowers at this period, there seems a certain amount of probability in favour of the correctness of Mr. Scudder's opinion as to the insect not being *Lepidopterous*.

Since the date of the discovery of *P. Oolitica*, another fragment of a supposed fossil butterfly has been found in the Stonesfield Slate, and is, or was until quite lately, in the possession of J. Parker, Esq., of Oxford. This fossil[2] has not yet, I believe, been figured or described.

LIAS AND RHÆTICS.

The Lias, including therein the Rhætic series, is in *this country*, the oldest formation of the Secondary Period in which fossil insects have been detected.

In some sections of this formation insect remains have been discovered in such abundance that the beds containing them have, as

[1] This is an error of Mr. Butler's: the insect was found at Aix, in Provence, in strata belonging to the Upper Eocene period.

[2] In January, 1878, I was informed by Prof. Westwood that this fossil was too fragmentary to admit of its being referred with certainty to the *Lepidoptera*, or any other order. Jan. '79.

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in the "Purbecks," been called the "Insect Limestone." Fossil insects have been found, chiefly in the lower division of this formation, in Gloucestershire,[1] Worcestershire, Warwickshire, Somersetshire, Dorsetshire and on the borders of Monmouthshire; a few have also been found in Yorkshire.[2] They are generally in a much more fragmentary condition than those from the "Purbecks," and are less common than in the latter formation.

Mr. Brodie states that he first discovered these interesting fossils in the immediate neighbourhood of Gloucester, and[3] he adds that some of the beds of limestone in the lowest division of the Lias, in the Vale of Gloucester, abound in insects, and that beautiful specimens, chiefly elytra and wings, have also been found in the Upper Lias at Dumbleton and Alderton.

At Dumbleton, which is N.E. of Cheltenham, Mr. Brodie obtained from the Upper Lias shales one nearly perfect *Neuropterous* insect, of which Professor Westwood[4] says—"It possesses an arrangement of the wing veins differing from that of any English species, and also from any foreign species known to me, but it comes nearest to the small *Libellulæ* forming the genus *Diplax*."

In the Upper and Middle portions of the Lower Lias, which are extensively developed in the neighbourhood of Gloucester and Cheltenham, traces of insects are said to be exceedingly scarce, but at Wainlode Cliff, on the banks of the Severn, near Gloucester, the Insect Limestone has produced remains of several genera of *Coleoptera*. In the Insect Limestone, to the South West of Combe Hill, not far from the last mentioned locality, Mr. Brodie obtained a great number and variety of insect remains, consisting

[1] In a note at p. 378 of the "Quart. Journ. Geol. Soc.," Vol. x., 1854, Prof. Westwood states that "A rich collection of fossil insects, from the Lias of Gloucestershire, &c., has been made by W. R. Binfield, Esq., to whom also the Museum of the Geol. Soc. is indebted for a suite of insects from the Lias of Lyme Regis." I am not aware that these insects have ever been described.

[2] The Rev. J. F. Blake has described and figured two fragments of insects from the Yorkshire Lias. One specimen consists of an elytron of a beetle, named by Mr. Blake *Buprestites bractoides*, and the other specimen consists of two wings of a *Neuropterous* insect, apparently belonging to some species allied to *Chauliodes*, which Mr. Blake has named *Chauliodites minor*. See "The Yorkshire Lias," by Ralph Tate, and J. F. Blake. London, 1876, p. 426, and plate xvi., figs. 5 and 6.

[3] See Brodie's "Fossil Insects," p. 51-103, and the "Quart. Journ. Geol. Soc.," Vol. iv., 1846, p. 14-16.

[4] See "Quarterly Journal of the Geological Society," Vol. v., 1849, p. 31-35.

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chiefly of the elytra of *Coleoptera* and a few imperfect but large wings of *Libellulidæ*.

At Apperley, near Wainlode Cliff, remains of insects have been found in plenty, many small slabs, three or four inches square, exhibiting several elytra and wings, and a few small Beetles.

From the Insect Limestone, near the village of Hasfield, Gloucester, many elytra of *Coleoptera* have been obtained. The same formation, in the neighbourhood of Forthampton near Tewkesbury, has also furnished fossil insects, belonging to the same families as those found in the localities before mentioned.

At Strensham, about nine miles from Evesham, insects have been obtained from a bed of Insect Limestone at the bottom of a large quarry. Amongst them was found part of the abdomen of a gigantic species of *Libellula*, which Mr. Brodie named *Libellula Hopei*. In the neighbourhood of Evesham the Insect Limestone has produced numerous remains of insects, the wings and elytra of many of which are said to be beautifully preserved. In the Lower division of the Lias, in this neighbourhood, Mr. H. E. Strickland[1] discovered small elytra of *Coleoptera* and portions of the wings of *Libellulidæ*.

From one quarry near Bidford, Warwickshire, Mr. Brodie obtained a small species of the family *Gryllidæ*, which he named *Gryllus Bucklandi* in honour of Professor Buckland.

In some of the quarries in this neighbourhood (Bidford) the wings of *Libellulidæ* were obtained not uncommonly, particularly at a place called the "Nook," where a beautiful specimen was found, which has been described and figured by Mr. Strickland.[2]

Mr. E. T. Higgins obtained from the Lower Lias or the Rhætics, in the Southern parts of Gloucestershire and the adjoining County of Somersetshire, in the neighbourhood of Bristol, numerous remains of insects. From Aust, near Bristol, and from Sudbury, on the Monmouthshire side of the Severn, about three miles from Chepstow, the Insect Limestone and the "Landscape Stone" have afforded a quantity of remains. In some slabs the insects were found embedded together in masses. In one slab Mr. Higgins is stated to have detected as many as 30 small Beetles.

[1] "Quart. Journ. Geol. Soc.," 1846, Vol. iv., pp. 14-16.

[2] See "The Annals and Magazine of Natural History," Vol. iv., p. 301, (new series).

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From the frequency of such delicate creatures as insects in the Landscape-stone, and in another band of limestone only a few feet higher, some of which are said to be beautifully preserved, and could not have been long subject to the action of the waves, it is supposed by Mr. Brodie, that this part of the Lias may have been formed in an estuary, which received the waters of some neighbouring coasts, and which brought down the remains of insects and plants.

The *Coleoptera* appear to have been abundant in the Lias, for out of some 300 specimens, or parts of specimens of insects obtained from this formation, examined by Professor Westwood, more than one third were referred by him to this Order, and included representatives of the *Buprestidæ*, *Elateridæ*, *Curculionidæ*, *Chrysomelidæ*, *Carabidæ*, *Telephoridæ*, &c. Most of the species appear to have been very minute, "never equalling in size," observes Mr. Westwood, "those from the Stonesfield Slate." The other orders represented in this formation are the *Orthoptera*, the *Neuroptera*, the *Hemiptera*, and (possibly) the *Diptera?*

The remains of *Orthoptera* include *Gryllidæ* and *Blattidæ*; the *Hemiptera* include *Cicada* and *Cimex*, and the *Neuroptera*, *Libellula*, *Agrion*, *Orthophlebia*, *Hemerobius*, *Æschna*, *Chauliodes* and *Ephemera*. Among these various families and genera we have omnivorous, herbaceous, and predaceous species. Many of the families and genera found in the Lias are common both to it and the Purbecks.

Although, as a rule, the remains of insects from this formation are very imperfect and fragmentary, the detached wings of many *Neuropterous* insects are preserved in the greatest perfection, and have the nervures of the wings beautifully defined. The size of the insects, judging from the remains, appears to have been usually small and indicative of a temperate climate.

It may be observed that nearly all the fossil insects from this formation have, with the exception of a few specimens from the Upper division, been obtained from the *lowest*[1] division of the Lias, or from the Rhætic series, between the Lias and the Trias. Remains of insects from the Lias and Rhætics are very numerous, but the majority of them are in such a fragmentary condition that

[1] Since this paper was read in January, 1878, I have received from Charles Moore, Esq., F.G.S., of Bath, a large collection of fossil insects from the *Upper* Lias of Ilminster. This collection includes *Coleoptera*, *Neuroptera*, *Orthoptera*, &c., all of which I hope shortly to describe.

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it has been impossible, even for those who have devoted special attention to the subject, to make out the species to which they belong. About 56 species, however, have been determined, which are distributed amongst five orders as follows, viz. :—

Coleoptera	... 29 species.		Hemiptera	... 6 species.
Neuroptera	... 12 „	(supposed)	Diptera?	... 2 „
Orthoptera	... 7 „			

No traces of *Lepidoptera* or *Hymenoptera* have been met with, and the remains which have been referred to the *Diptera* are extremely doubtful.

CONTINENT OF EUROPE.

CRETACEOUS.

As the Upper Cretaceous Rocks are, for the most part, of marine origin remains of insects are, of course, very rarely met with in them.

From certain beds of sand in the neighbourhood of Aix la Chapelle, which have been referred to the Upper Cretaceous Period, Dr. Debey[1] obtained about ten species of *Coleoptera*, chiefly *Curculionidæ* and *Carabidæ*.

Professor Pictet[2] states that M. Desmoulins found elytra of *Coleoptera* in the Chalk Marl of the Mountain of St. Catherine, near Rouen.

Dr. Geinitz has called attention to the remains of perforated wood in the Upper and Lower Greensands of Saxony, which he considers to be evidence of the existence of Longicorn Beetles at this period. He believes that the insects, which made these perforations, belonged to the *Cerambycidæ*.

M. Charles Brongniart[3] in April, 1876, called the attention of the Entomological Society of France to a piece of fossil wood, obtained from the Gault of Lottinghem, Pas de Calais, containing numerous perforations. M. Brongniart believes these perforations to have been made by some species of beetle belonging to the genus *Hylesinus*, of the family *Scolytidæ* (Xylophaga.)

[1] Lyell's "Elements," 6th edit., page 331.
[2] "Traité élémentaire de Paléontologie," Vol. iv., pp. 95 and 102.
[3] See "Les annales de la Société Entomologique de France," V^e^ serie., p. 217. 1876.

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UPPER OOLITE.

Solenhofen Slate.

The most celebrated formation of this period on the Continent, from which fossil insects have been obtained in any number, is that of the well-known lithographic stone of Solenhofen,[1] in Bavaria.

The oldest account of fossil insects from this formation is found in Schröter's [2] "Real-und verbal Lexicon," published in 1779. In 1783 Esper [3] referred to the discovery of a species of *Gryllus* in the Solenhofen Slate; and in 1826 [4] Van der Linden described a *Neuropterous* insect from Solenhofen, as *Æschna antiqua*.

Reference to fossil insects from the Solenhofen slate is also made by Marcel de Serres,[5] in 1829; and Bronn,[6] in 1835, enumerated *Coleoptera*, *Neuroptera*, *Hymenoptera* and *Lepidoptera* (?) from the same formation.

In 1839[7] Professor Germar[8] published descriptions of 17 species from Solenhofen, including *Coleoptera*, *Orthoptera*, *Neuroptera*, *Hymenoptera*, *Hemiptera*, and *Diptera*. Several species from this locality were also described (in 1841) by Count Münster,[9] including a *Lepidopterous* (?) insect,[10] which he referred to the *Tineina*.

[1] Of this formation, Lyell observes — "Although the number of *Testacea* in this Slate is small, and the plants few, and those all marine, Count Münster had determined no less than 237 species of fossils, including 26 species of insects. These insects, among which is a *Libellula* or dragon-fly, must have been blown out to sea, probably from the same land to which the flying lizards and other contemporaneous reptiles resorted."

[2] "Real und verbal Lexicon," 1779, II., s. 93; III., s. 72; and in "Neue Literatur und Beiträge zur Kenntniss," Leipsic, 1784, I. c., 410.

[3] "De animalibus oviparis," pp. 18-19, Erlangæ, 1783.

[4] "Mem. Acad. Brux.," Vol. iv., p. 247, 1826.

[5] "Géognosie des terrains Tertiares," &c Livre iv^me. Sec. iii., p. 244, 1829.

[6] "Von Insekten einege *Käfer (Cerambyx, Hydrophylus), Neuropteren (Libellula, Aeschna, Agrion, Myrmeleon), Hymenopteren (Sirex, Ichneumon). Schmetterlinge (Sphynx)*," &c. "Lethea Geognostica," Vol. i., p. 210. 1835-1837. (See also Quenstedt. "Handb. d. Petrefaktenk.")

[7] "Nova Acta. Akad. Leopold. Carol.," 1839, xix., 2 s., 187-222, t. 21-23.

[8] Dr. Hagen observes of these insects:—"The species described by Germar, in the 'Acta Acad. Leop.,' to which hitherto reference has always been made, are described from specimens, the outline of which has been artistically painted and completed. I have often examined the types carefully, and can certainly maintain that this account of them is correct." "Entomologists Annual," 1862, p. 1.

[9] "Beiträge zur Geognosie und Petrefactenkunde," Bayreuth, 1841.

[10] Of this insect M. Pictet observes, "Le Comte de Münster a décrit, sous le nom de '*Tineites Lithophilus*' un insecte des Schistes Lithographiques de Bavière, qu'il considére comme appartenant à la famille de Tineides, mais que la vue de la figure me ferait plutot considerer comme un *Termes*." —"Traité de Paléontologie," Vol. iv.. p. 111.

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Dr. Giebel, in his "Fauna der Vorwelt,"[1] (Insecten und Spinnen), published in 1856, enumerates 26 species from Solenhofen, including—

Coleoptera	2 species.	Hemiptera	4 species.
Orthoptera	4 „	Lepidoptera (?) ...	1 „
Neuroptera	12 „	Diptera	2 „
Hymenoptera ...	1 „		

Dr. Hagen,[2] who has paid especial attention to the Solenhofen *Neuroptera*, has described 33 species of that Order, and has also given a list of 36 species contained in the Royal Collection in the Academy of Munich.

Of the 36 species of *Neuroptera* in the Munich Collection, Dr. Hagen states that 27 are dragon flies, some of which belong to extinct genera, but others to such as now live in America and Australia; he also[3] adds that many of the fossil insects from this formation, preserved in the Munich Collection, and in the Collection of Dr. Krantz, of Bonn, are in a splendid state of preservation. One-third of the entire collection is *Libellulidæ*, another third consists of *Orthoptera* and *Hemiptera* (especially gigantic species of *Belostoma*, *Pygolampos* and *Nepa*); and the remaining third consists of *Coleoptera*, *Hymenoptera* and *Diptera*. Out of 450 specimens of fossil insects in the Munich Collection 150 are *Neuroptera*, and out of these 136 belong to the *Odonata*.

The *Odonata*, according to Hagen, comprise the following, viz:—

Libellulina	4 species.	Calopterygina ...	11 species.
Æschnina	1 „	Agrionana	4 „
Gomphina	7 „		

The *Gomphidæ* are said to belong principally to species referable to genera similar to *Petalia*, *Phenes*, and *Petalura*, of which a few species occur at the present day in Chili and Australia. The fossil *Gomphina* of Solenhofen, are generally very large, and some are truly gigantic[4]—four inches in length, with an expanse of wings of $7\frac{1}{2}$ inches.

Of the *Calopterygina*, the group *Heterophlebia* contains some of

[1] "Fauna der Vorwelt," II. (Die Insecten und Spinnen der Vorwelt), s. 392 to 426. 1856.

[2] "Ueber die Neuropteren aus dem lithographischen Schiefers in Bayern," in "Palæontographica," Vol. 10, pp. 96-145. 1862. "Palæontographica," Vol. XV., 1865-1868, and the "Entomologists' Annual," for 1862.

[3] See "Entomologists' Annual," for 1862.

[4] See the plates accompanying Dr. Hagen's papers, in "Palæontographica," Vols X. and XV., antea cit.

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the most gigantic *Neuroptera*—two of them belong to the largest known *Odonata*, having an expanse of wing of 7½-8 inches, and bodies 3¾-4 inches in length.

From a study of the fossil insects from the Solenhofen Slate, and a comparison of them with those from the English formations of the same age, Dr. Hagen has drawn two conclusions, viz. :—(First.) That the two fauna are very closely allied, and that possibly some species occur in both formations. (Secondly.) That the fauna of the English and Bavarian strata are not only quite distinct from the existing fauna, but also from those of Aix; of the Rhenish peat deposit (Brown Coal of the Rhine); of Œningen and Radoboj; and from that of the Amber; differing not only in species but in genera.

Another large collection of fossil insects from Solenhofen is contained in the Teyler Museum at Harlem. Upwards of 80 species in this collection have been described by Herr H. Weyenbergh[1] junr., in the "Archives du Musée Teyler," and are enumerated by Dr. Winkler,[2] in his 2nd Supplement to the "Catalogue Systématique de la Collection Paléontologique du Musée Teyler."

The species obtained from the Solenhofen Slate which have up to the present time been described by Prof. Germar,[3] Count Münster,[4] Herr Carl von Heyden,[5] Dr. Giebel,[6] Dr. Hagen,[7] and Herr H. Weyenbergh,[8] amount in number to 114[9] and are distributed amongst the existing Orders as follows:—

Coleoptera	29 species.	Diptera	5 species.
Neuroptera	46 „	Hymenoptera ...	5 „
Orthoptera	11 „	Lepidoptera ...	2 „
Hemiptera	16 „		114

[1] "Sur les Insectes fossiles du calcaire lithographique de la Bavière qui se trouvent au Musée Teyler" Archives du Musée Teyler.—Vol. ii., pp. 247-294, 1869. Vol. iii., pp. 234-240, and "Period Zool. Arg." t. 1.

[2] "Catalogue Systématique de la Collection Paléontologique du Musée Teyler." Harlem 1876, (Deuxième Suppt.)

[3] "Nova Acta. Acad. Nat. Cur." T. xix. 1839.

[4] "Beiträge zu Geog. und Petref," 1841.

[5] "Palæontographica." Vol. i. pp. 99-101, 1851.

[6] "Fauna der Vorwelt." Vol. ii., 1856. and "Zur fauna des Lithographischen Schiefers von Solenhofen." 1857.

[7] "Enumeration des Odonates fossiles d'Europe" "Revue des Odonates" by E. de Selys-Longchamps, pp. 356-364, 1850; "Palæontographica," Vol. x., 1861. 1863; Vol. xv., 1865, 1868; and the "Entomologists' Annual." 1862.

[8] "Archives du Musée Teyler," &c., antea cit.

[9] For lists of species see post pages 35 & 36.

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This list is especially important, as it includes two undoubted species of *Lepidoptera*.

LIAS.

From the lower marls of the Lias, at Schambelen in the Canton of Aargau, in Switzerland, about 2,000 specimens of fossil insects have been obtained. These specimens have been carefully studied by Professor Heer, who is of opinion that this locality is the only one on the Continent, in which so large a number of primæval insects have been preserved to our time.[1]

The 2,000 specimens comprise 143 species, which are distributed as follows :—

	Species.		Species.
Coleoptera	... 116	Hemiptera ...	... 12
Orthoptera	... 7	Hymenoptera ? (very	
Neuroptera... ...	... 7	doubtful) ...	... 1
			143

No *Lepidoptera* or *Diptera* have as yet been discovered. One small wing is described as being that of a *Hymenopterous* insect, but as no remains of the *Hymenoptera* have been obtained elsewhere from strata of this period—even in those localities in which insect remains have been found in abundance—it is probable that this wing belonged to an insect of another Order.

The *Coleoptera*[2] are represented by some sixteen families, amongst which are *Carabidæ, Gyrinidæ Cryptophagidæ, Nitidulidæ, Peltidæ, Cistelidæ, Rhyncophora, Chrysomelidæ, Byrrhidæ, Hydrophilidæ, Buprestidæ, Elateridæ, Telephoridæ*, &c.

The presence, in large numbers, of those beetles whose larvæ are wood feeders, and who in their perfect state are usually found on or under the bark of trees, is evidence of the existence of woods or forests during this period; and the presence of several genera of fungus beetles implies the existence of fungi. The *Buprestidæ* are represented by 33 species. Of the *Byrrhidæ* four species have been found in this formation; three of them—*Byrrhidium arcuatum, B. morio*, and *B. troglodytes*—are among the most abundant insects at Schambelen, and as they are all moss feeders, Professor

[1] "Urwelt der Schweiz," *antea cit.*
[2] For list of families, see post-page 36.

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Heer supposes that the ground and the trees were more or less covered with mosses, although no remains of these plants have been preserved. The leaf-eating beetles are represented by, amongst other species, two of the family *Chrysomelidæ*. Of Carnivorous beetles 29 species have been found, and the Water-beetles are represented by some 20 species.

The *Orthoptera* comprise three species of *Blattidæ* (cockroaches), three grasshoppers, and one earwig; and the *Neuroptera* are represented by six species of *Termites* (or white ants) and one dragon fly—*Æschna Hageni*—which is perhaps larger than any living[1] species, except *Gynacantha plagiata*.

The *Hemiptera* include nine species, distributed amongst the *Cercopidæ*, *Lygæidæ*, and *Cicadidæ*.

Dr. Heer observes that it may be safely inferred from the richness of the insect fauna that the land was of considerable extent. Some of the insects are of large size, but the majority are small, some even smaller than the smallest of the allied species of the present day, as is also the case with the insects of the English Lias. Judging from the size of the Liassic insects, one would infer a temperate climate, but the numerical proportion existing between certain families tends to the conclusion that a warmer climate then prevailed.

So far as I am aware the only other locality on the Continent in which insect remains have been discovered in the Lias, is Bayreuth,[2] where Count Münster is said to have detected traces of wings of insects.[3]

TRIAS.

No traces of insects have as yet been found in the Triassic rocks of the United Kingdom, and only seven specimens have been recorded from Continental Europe. Of these seven specimens three have been referred to the *Coleoptera*, three to the *Neuroptera*, and one to the *Orthoptera*.

The three species of *Coleoptera* have been described by Dr.

[1] See plate iv. in pt. 1, "Trans. Ent. Soc., London," 1878.
[2] Bronn's "Lethea Geognostica," Vol. i., p. 210.
[3] Since this paper was read in January, 1878, seven species of *Coleoptera* have been described by Dr. Heer from the Rhætic formation of Schonen, in Sweden. (See "Aftryck ur Geol. Föreningens i Stockholm Förhandl," 1878, No. 49, Bd. iv., No. 7).

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Heer,[1] and respectively named *Glaphyroptera pterophylli*, *Curculionites prodromus*, and *Chrysomelites*[2] *Rothenbachi*; the two first-named were discovered in the Keuper of Vadutz, and the third specimen was obtained from the Keuper of Rothenbach.

The three specimens of *Neuroptera*[3]—*Chauliodites Picteti*, *C. Zinckeni*, and *C. Helveticus*—have also been described by Dr. Heer. The two first named specimens were obtained from the Bunter of Trebitz and Salzmunde, and the third specimen from the Keuper.

The only *Orthopterous* insect from the Trias was also obtained from the Bunter of Trebitz. It belongs to the family *Blattidæ* and has been described[4] by Dr. Heer, who placed it in a new genus —*Legnophora*—and named it *Girardi*, after Prof. Girard, of Halle, in whose collection it was discovered.

This specimen concludes the scanty list of fossil insects obtained from the Trias of Continental Europe.

AMERICA.

TRIAS.

In the "Geological Magazine" for May, 1868, Mr. Scudder records one species of *Coleoptera* from the Trias of North America, and he observes that "in the Triassic rocks of the Connecticut Valley some questionable tracks have been referred by Hitchcock to Insects[5] and Myriopods."

I have lately been informed[6] by Mr. Scudder that a vast quantity of insects from Secondary rocks have been recently discovered in America, and will be described by him in due course.

The following is, I believe, a complete list of all the fossil insects which have, up to the present time, been described from the Secondary formations of the United Kingdom and the Continents of Europe and America.

[1] See "Le Monde Primitif de la Suisse," p. 99; "Neuer Denkschriften der Schweiz Naturforsch Gesellschaft." xiii, 1853 (figured in Taf. vii.).

[2] "Flora Foss. Helveticæ," p. 76, Taf. xvii., 1877.

[3] "Vierteljahrsschrift der Naturforschenden Gesellschaft in Zurich," p. 279. 1864.

[4] "Vierteljahrsschrift der Naturf. Gesellsch. in Zurich," 1864, *antea cit.*

[5] See also Dana's "Manual of Geology," 1874, p. 411.

[6] *In litt.*

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A LIST OF INSECT REMAINS DISCOVERED IN THE FORMATIONS OF THE SECONDARY OR MESOZOIC PERIOD.

EUROPE.

GREAT BRITAIN.

LOWER CRETACEOUS OR NEOCOMIAN.

From Ironstone[1] and Shales at the "Govers," near St. Leonards-on-Sea :—

Elytra of Coleoptera and wings or parts of wings of Coleoptera, Neuroptera and Diptera.

From the Wealden Marlstone between Tonbridge and Maidstone :—

Elytra of Coleoptera.

From the Wealden of the Isle of Wight :—

Elytra of Coleoptera.

From the Wealden of Punfield Bay, Swanage, Dorsetshire :—

Elytra and wings of insects.

UPPER OOLITE.

Middle and Lower Purbecks.

From Durl'stone Bay, Swanage, Dorset :—

Coleoptera.[2]

Hydrophilus Brauni.	Cymindis Beyrichi.
Hydroporus Neptuni.	,, antiqua.
Carabus Westwoodi.	Buprestium gorgus.
Carabidium Dejeananum.	,, stygnus.
Harpalus Knorri.	,, Woodlei.
,, Ewaldi.	,, dardanus.
,, anactus.	,, bolbus.
,, Burmeisteri.	Ancylochira teleas.
Harpalidium nothrus.	Agrilus strombus.

[1] See a paper "On the occurrence of Fossil Insects in the Wealden Strata of the Sussex Coast" "Quart. Journ. Geol. Soc.," Vol. x., p. 171, 1854.

[2] This list is compiled from Prof. Westwood's paper in the "Quart. Journ. Geol. Soc.," Vol. x., Nov., 1854; and from Dr. Giebel's "Fauna der Vorwelt" (Insekten und Spinnen), pp. 187, 393-426.

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Agrilus stomphax.
„ cyllarus.
„ cyllabacus.
Elaterium pronæus.
„ triopas.
„ barypus.
„ Oweni.
„ Morrisi.
Tentyridium peleus.
Crypticus Ungeri.
Helopium agabus.
Diaperidium mithrax.
Chrysomela Dunkeri.
„ dubia.
„ ignota.
„ tertiaria.
Coccinella Neptuni.
„ Perses.
Prionus antiquus.
Lamia Schroeteri.
Curculionites Syrichthys.
„ Westwoodi.
„ tuberculatus.
„ marginatus.

ORTHOPTERA.

Gryllidium Oweni.
Mantis ? (undetermined).
Blattina anceps.
„ recta.
Rithma Westwoodi.
„ Purbeccensis.
Rithma Murchisoni.
„ Morrisi.
„ antiqua.
„ ramificata.
Nethania Molossus.
Blatta elongata.

NEUROPTERA.

Ela brephos.
Elcana tessellata.
„ Beyrichi.
Abia Sipylus.
„ duplicata.
Hagla ignota.
Chimarrha Pytho.
Libellula agrias.
Libellulium Kaupi.
Estemoa Bubas.
Phryganidæ.

HEMIPTERA.

Naurocoris ?
Lygæites Dallasi.
„ furcatus.
„ priscus.
Cicada psocus.
Cercopis Mimas.
Cercopis Telesporus.
„ Schæfferi.
„ Signoreti.
Cercopidium Hahni.
„ trigonale.

DIPTERA.

Simulidium priscum.
Thiras Westwoodi.
Corethrium pertinax.
Campylomyza grandæva.

HYMENOPTERA.

Ponera Brodieri.
Myrmica Heeri.

LEPIDOPTERA ?

Cyllonium Boisduvalianum.
Cyllonium Hewitsonianum.

Professor Westwood[1] has named and also figured the

[1] See "Quart. Journ. Geol. Soc.," 1854, Vol. x., pp. 393-397.

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following species from the Middle and Lower Purbecks of Dorset :—

Elaterium pronæus.
Helopium agabus.
Curculium Syrichthus.
Formicium Brodiei.
Buprestium Woodlei.
„ teleas.
Blapsium Egertoni.
Harpalidium anactus.
Tentyridium peleus.
Corethrium pertinax.
Cercopidium mimas.
„ telesphorus.
Libellulium agrias.
Œschnidium bubas.
Cicadellium dipsas.
„ psocus.
Buprestium gorgus.
Diaperidium mithrax.
Simulidium priscum.
Termitidium ignotum.
Panorpidium tessellatum.
Cecidomium grandævum.
Blattidium molossus.
Elaterium triopas.
„ barypus.
Buprestium stygnus.
„ vulgus.
„ dardanus.
Agrilium stygnus.
„ stomphax.
„ cyllarus.
„ cyllabacus.
Ctenicerium blissus.
„ hylastes.
Harpalidium nothrus.
Telephorium abgarus.
Buprestium bolbus.
Panorpidium tessellatum.
Cimicidium Dallasi.
Raphidium brephos.
Cyllonium Boisduvalianum.
„ Hewitsonianum.
Gryllidium Oweni.
Libellulium Kaupii.
Carabidium dejeananum.
Cercopidium Hahnii.
„ Schæfferi.
„ Signoreti.
Nepidium Stolones.
Myrmicium Heeri.
Blattidium nogaus.
„ achelous.
„ symyrus.
Phryganeidium Pytho.
Agronidium Ætna.

List of insect remains, chiefly from the Lower Purbecks of Wilts and Bucks, extracted from Brodie's "Fossil Insects," and his paper on "The Distribution and Correlation of Fossil Insects" :—

(1.) Coleoptera.

Carabidæ.
Staphylinidæ.
Cerylon.
Helophorus.
Cyphon.
Rhyncophora.
Buprestidæ.
Tenebrionidæ.
Harpalidæ.
Colymbetes.
Elateridæ.
Curculionidæ.
Limnius.
Cantharidæ.
Hydrophilidæ.
Helophoridæ.

(2.) Orthoptera.

Acheta.
Blatta.

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(3.) Neuroptera.

Leptoceridæ.	Œschna.
Phryganeidæ.	Lindeniæ.
Termes.	Libellula.
Corydalis.	

(4.) Hemiptera.

Kleidocerys.	Cercopis.
Cixius?	Cicada.
Ricania.	Delphax.
Asiraca.	Velia.
Aphis.	Hydrometra.
Cimicidæ.	Molobius.

(5.) Diptera.

Simulium.	Chironomi.
Platyura.	Culex.
Tanypus.	Chironomus.
Empidæ.	Rhyphus.
Sciophila.	Macropeza.
Macrocera.	Tipulidæ.

From the Lower Purbecks of the Vale of Wardour, in Wiltshire:—

Coleoptera. [1]

Elmis Brodiei.	Philonthus Kneri.
Helophorus antiquus.	Prognatha crassa.
„ Brodiei.	Elater Purbeccensis.
Hydrobius Purbeccensis.	„ Werneri.
Hydrophilus Westwoodi.	Cyphon vetustus.
„ Brodiei.	Meloe Hoernesi.
Carabus elongatus.	Tenebrio rugoso-striatus.
Camptodontus Angliæ.	Cerylon striatum.
Cymindis antiqua.	Hypera antiqua.

Orthoptera.

Gryllus Sedgwicki.	Elisama minor.
Blattina Stricklandi.	Blatta pinna.
„ similis.	„ Kollari
„ recta.	„ Ungeri.
Elisama Kneri.	„ pluma.

Neuroptera.

Bittacus dubius.	Æschna perampla.
Panorpa gracilis.	Libellula petrificatus.
Orthophlebia bifurcata.	„ jurassica.
„ minuta.	„ antiqua.
Zalmona Brodiei.	Termes grandævus.

[1] This list is compiled from Brodie's "Fossil Insects," his paper on the "Correlation of Fossil Insects," and Dr. Giebel's "Fauna der Vorwelt."

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HEMIPTERA.

Hydrometra?	Asiraca Kengotti.
Cicada punctata.	Delphax pulcher.
Flata Haidingeri.	Cercopis lanceolata.
Ricania fulgens.	Aphis valdensis.
Cixia maculata.	„ plana.
Asiraca Egertoni.	„ dubia.

DIPTERA.

Remalia sphinx.	Adonia Fittoni.
Hasmona leo.	Chironomus extinctus.
Bria prisca.	„ arrogans.
Simulidium humidum.	Macropeza prisca.
Thimna defossa.	Asuba Brodiei.
Sama rustica.	Dara fossilis.

From Lower Purbecks (Ridgway Quarries, near Dorchester):—

Numerous elytra of Coleoptera
And a fragment of the wing of a Neuropterous insect.

From Purbeck (?) strata in the neighbourhood of Swindon, Wilts :—

Elytra of Coleoptera.

KIMMERIDGE CLAY.

From a block of Septaria in the Kimmeridge Clay, near Ringstead, Dorsetshire :—

Fragment of an elytron of a small beetle. [1]

MIDDLE OOLITE.

OXFORD CLAY.

From the Oxford Clay near Christian Malford :—

Supposed larva of an insect, possibly a *Libellula*.

LOWER OOLITE.

FOREST MARBLE.

From quarries at Farleigh, near Bath :—

Elytra of Coleoptera and small wings. [2]

GREAT OOLITE.

From the Eastern Moorlands of Yorkshire :—

Elytra of Coleoptera.

[1] "Quart. Journ. Geol. Soc.," 1853.
[2] Brodie's "Fossil Insects," p. 37.

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Stonesfield Slate.

From the Stonesfield Slate, Stonesfield, Oxfordshire, and Sevenhampton and Eyeford, Gloucestershire:—

Coleoptera.[1]

Blapsidium Egertoni.	Blapsidæ ? (Elytra f.)
Buprestidæ.	Prionus ooliticus (Brod.)
Curculionidæ.	Pimeliidæ ?
Melolonthidium.	Chrysomelidæ ?
Prionideum.	Coccinella ? Wittsii.

Neuroptera.

Hemerobioides giganteus.	Libellulæ ? (two wings of.)
Libellula Westwoodi.	

Lepidoptera. ?

Palæontina oolitica.[2]	And wing of Lepidopterous ? insect unnamed.[3]

LIAS.

List of Insects from the English Lias, extracted from the Rev. P. B. Brodie's[4] paper on "The Distribution and Correlation of Fossil Insects :—"

Insects.	*Locality.*	*Geological Horizon.*
Libellula.	Dumbleton.	Upper Lias.
„ (Heteroplebia) Brodiei.	„	„
Œschna.	„	„
Agrion.	„	„
Orthoptera.	„	„
Blattidæ.	„	„
Beetles of several genera.[5]	ditto.	Upper Lias.
	and Alderton.	
Body of gigantic Libellula.	Strensham.	
Libellula.	Strensham.	Lower Lias.
Orthoplebia,	Wainlode, Forthampton, Bidford, Brown's wood, Strensham, Cracombe, and Somersetshire.	ditto.

[1] This list is compiled from Brodie s "Fossil Insects," and his paper on the "Correlation of Fossil Insects"

[2] P. oolitica (Butler), Stonesfield Slate. "Geol. Mag.,' Oct., 1874. Plate xix.. figs. 4 and 5.

[3] Wing of supposed Lepidopterous insect, from Stonesfield Slate, Oxford, in the collection of J. Parker, Esq., of Oxford.

[4] "Proceedings of the Warwickshire Naturalists' and Archæologists' Field Club," 1874.

[5] This list is simply *extracted* from Mr. Brodie's before-mentioned paper. No attempt has been made to amend the arrangement, or to correct any but clerical errors.

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Insects.	*Locality.*	*Geological Horizon.*
Œschna.	Bidford.	Lower Lias.
Chauliodes.	Brown's wood, Hasfield, Strensham, Binton, Copt Heath, Knowle.	ditto.
Ephemera.	Strensham, Brown's wood, Binton, Westbury.	ditto.
Myrmeleon ?	Binton.	ditto.
Trichopterous.	Grafton.	ditto.
Libellulideous wings, chiefly,	Strensham, Brokeridge, Binton, Wilmcote, Grafton, Brown's wood, Barrow on Soar.	ditto.
Hemerobius (wing of), most nearly allied to the recent Polystæchetes. (Scudder).		ditto.
	COLEOPTERA.	
Carabidæ.	Apperley, Brockeridge.	ditto.
Harpalideous Carabidæ.	Binton, Wilmcote.	ditto.
Buprestidæ or Elateridæ.	Vale of Gloster near Churchdown.	Lima beds.
Elytra of two or three other genera.	The Leigh.	Lima shales.
Buprestidæ or Elateridæ.	Wainlode, Apperley, Brockeridge.	Lower Lias.
Elateridæ.	Wainlode, Apperley, Westbury.	ditto.
Buprestidæ.	Strensham.	ditto.
Gyrinus.	Forthampton.	ditto.
Ditto, like a foreign species.	Norton.	ditto.
Pentatomidæ (body of).		
Telephoridæ.	Forthampton, Wainlode, Brown's wood.	ditto.
Curculionidæ or Chrysomelidæ.	Apperley, Hasfield.	ditto.
Chrysomelidæ.	Forthampton.	ditto.
Aquatic Beetle.	Wainlode.	ditto.
Laccophilus (Dyticidæ).	Hasfield.	ditto.
Melolontha.	Cracombe.	ditto.
Trogulus.	Strensham.	ditto.
Tettigonia (Pupa of).	Wainlode.	ditto.
Elater or Buprestis. (large entire beetle.)	Strensham.	ditto.
Elytra of several species.	Westbury	ditto.
Elytra of two species of Coleoptera.	Hotham, Yorkshire.	ditto.
Under wings of Beetles.		ditto.
Upper surface of anal segment of a Beetle.	Hotham.	ditto.

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ORTHOPTERA

Insects.	*Locality.*	*Geological Horizon.*
Species of (Orthoptera).	Grafton.	Lower Lias.
Gryllidæ.	Wilmcote, Binton, Apperley, Grafton, Forthampton.	ditto.
Blattidæ.	Wainlode, Strensham.	ditto.
Locusta ? (under wing.)	Strensham.	ditto.

HEMIPTERA

Cicada.	Hasfield.	ditto.
Belostoma.	Wainlode.	ditto.
Hemielytra of a Cicada like Meloe.	Forthampton, Apperley, Wainlode.	ditto.
Cimex.	Strensham.	ditto.
Gigantic Homoptera.	Binton,	ditto.
Homopterous larva.	Strensham.	ditto.

DIPTERA.

Asilus.	Forthampton.	ditto.
Tipula (entire insect head, antennæ and wings.)	Strensham.	ditto.
Diptera (entire), undetermined.	Wainlode, Apperley.	ditto.

List of insect remains from the English[1] Lias and Rhætics compiled from Dr. Giebel's "Fauna der Vorwelt," &c.:—

COLEOPTERA.

Melolontha greithana.
Berosus liasinus.
Buprestites bractoides.
Gyrinus natans.
„ dubius.
Laccophilus aquaticus.
Harpalus Heeri.
„ liasinus.
„ Schlotheimi.
Ancylochira liasina.
Elater vetustus.
„ socius.
„ Neptuni.
„ Redtenbacheri.
„ angulatus.
„ varius.
Telephorus Haueri.
Chrysomela Andraei.
„ liasina.

NEUROPTERA.

Elcana Beyrichi.
Orthoplebia longissima.
„ communis.
„ parallela.
„ similis.
„ intermedia.
„ lata.
Orthoplebia furcata.
„ liasina.
Hemerobius Higginsi.
Hagla gracilis.
„ similis.
„ deleta.
„ ignota.

[1] Wainlode Cliff, Apperley, Hasfield, Tewksbury, Forthampton, and other parts of Gloucestershire, Worcestershire, Warwickshire, Somersetshire Monmouthshire, and Yorkshire.

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Diastatomma liasina.
Libellula Brodiei.
„ Hopei.
Heterophlebia dislocata.
Heterophlebia Buckmanni.
„ Westwoodi.
Rapha liasina.
Chauliodites minor.

ORTHOPTERA.

Akicera Heeri.
„ Frauenfeldi.
Blattina liassina.
„ incompleta.

HEMIPTERA.

Pachymerus Zucholdi.
Belostomum liasinum.
Cicada Murchisoni.

DIPTERA ?

Asilus ignotus ?

CONTINENT OF EUROPE.

CRETACEOUS.

From beds of sand in the neighbourhood of Aix la Chapelle:—
Several species of Coleoptera, chiefly Curculionidæ, and Carabidæ. [1]

From the Chalk Marl of the Mountain of St. Catherine, near Rouen :—

Elytra of Coleoptera. [2]

From the Gault[3] of Lottinghem, Pas-de-Calais :—

Traces of Coleoptera, supposed to belong to the genus *Hylesinus* of the *Scolytidæ*.

From the Upper and Lower Greensands of Saxony:—

Traces of Longicorn Beetles, supposed to be *Cerambycidæ*.

UPPER OOLITE.

SOLENHOFEN SLATE.

List of genera of insects from Solenhofen and Pappenheim, compiled from Bronn's "Lethæa Geognostica," Vol. i, p. 210 (1835-1837).

COLEOPTERA.

Cerambyx.
Hydrophilus.

NEUROPTERA.

Libellula.
Œschna.
Agrion.
Myrmeleon.

HYMENOPTERA.

Sirex.
Ichneumon.

LEPIDOPTERA.

Sphinx ?

List of the fossil insects from Solenhofen, described by Prof.

[1] "Lyell's Elements," 6th edit, p. 331.
[2] "Traité élémentaire de Paléontologie," Vol. iv, pp. 95 and 102.
[3] "Ann. Soc. Ent. de France." 1876, p. 217.

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Germar, in the "Nova Acta" of the Academy of Leopold Charles of Austria, 1839, xix, 2 s, 189-222.

Locusta speciosa.
„ priscus.
Chresmoda obscura.
Ditomoptera dubia.
Belostomum elongatum.
Nepa primordialis.
Pygolampis gigantea.
Cerambycinus dubius.
Apiaria antiqua.
Sciara prisca.
Æschina Munsteri.
„ gigantea.
Libellula longialata.
Agrion Latreillei.
Scarabæides deperditus.
Ricania hospes.
Musca lithophila.

Fossil insects from Solenhofen, enumerated by Dr. Giebel, in his "Fauna der Vorwelt" (Insecten und Spinnen):—

COLEOPTERA.

Scarabæides deperditus.
Mesosa Germari.

ORTHOPTERA.

Phaneroptera Germari.
Locusta prisca.
Chresmoda obscura.
Decticus speciosus.

NEUROPTERA.

Agrion vetustum.
Diastatomma Münsteri.
Æschna Charpentieri.
„ Schmideli.
„ antiqua.
„ Parkinsoni.
Æschna longialata.
„ gigantea.
„ ntermedia.
„ Buchi.
„ bavarica.
Libellula Koehleri

HYMENOPTERA.

Apiaria antiqua.

HEMIPTERA.

Pygolampis gigantea.
Nepa primordialis.
Belostomum elongatum.
Ricania hospes.

DIPTERA.

Musca lithophila.
Sciara prisca.

The following list of fossil insects from Solenhofen includes (to the best of my knowledge) every species which has, up to the present date, been described by Professor Germar,[1] Count Münster,[2] Herr Carl von Heyden,[3] Dr. Giebel,[4] Dr. Hagen,[5] and Herr Weyenbergh, jun.[6]

[1] "Nova. Acta." Acad. Nat. Cur. T. xix., 189-222. 1839.
[2] "Beiträge," T. v. 1841.
[3] "Palæontographica," Vol i., pp. 99-101. 1851.
[4] "Fauna der Vorwelt," Vol. ii. 1856. "Zur Fauna des Lithographischen Schiefers von Solenhofen." 1857.
[5] "Enumeration des Odonates Fossiles d'Europe." "Revue des Odonates," by E. de Selys-Longchamps, pp. 356-364. 1850. "Palæontographica," Vol. x., pp. 96-145. 1861-1863, and Vol. xv., pp. 59-96, 1865-1868.
[6] "Archives du Musée Teyler," Vol. ii., pp. 247-294. 1869. Vol. iii., pp. 234-240, and "Period. Zool. Arg." t. i. (See also "Catalogue systématique de la Collection Paléontologique du Musée Teyler," 1876, by Dr. Winkler.

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COLEOPTERA.

Mesosa Germari.
Chrysobothrys veterana.
Ditomoptera dubia.
Carabicina decipiens.
Scarabæides deperditus.
Carabus Winkleri.
Hydroporus petrefractus.
Gyrinus (?) Jurassicus.
Silpha tennilythris.
Scaphidium Hageni.
Hister relictus.
Meloe Bavaricus.
Oryctes Pluto.
Cetonia (?) defossa.
Buprestis lapidelythris.
Lacon petrosum.
Elater Teyleri.
„ Costeri.
„ grossus.
Tenebrio innominatus.
Anisorhynchus (?) lapideus.
Saperdides cristallosus.
Leptura primigenia.
Cryptocephalus antiquus.
„ mesozoicus.
Chrysomela lithographica.
„ rara.
Cassida æquivoca.
Coccinella Heydeni.

NEUROPTERA.

Isophlebia Aspasia.
„ Helle.
Stenophebia æqualis.
Heterophlebia dislocata.
„ Amphitrite.
„ Phryne.
„ eximia.
„ casta.
Euphœa multinervis.
„ filosa.
„ areolata.
„ longiventris.
Agrion hecticum.
„ exhaustum.
„ Eichstättense.
„ vetustum.
Anax Charpentieri.
Petalia longialata.
Petalura gigantea.
„ latialata.
„ eximia.
„ intermedia.
„ Münsteri.
Petalura varia.
„ differenz.
Libellula (?) densa.
„ abscissa.
„ nævia.
„ valga.
Termes heros.
„ lithophilus.
„ fossilis.
Ephemera cellulosa.
„ procera.
„ mortua.
„ prisca.
„ Meyeri.
„ deposita.
Hemerobius priscus.
„ fossilis.
Chrysopa protogaea.
„ Solenhofensis.
Apochrysa excelsa.
Nymphes fossilis.
Myrmeleon extinctus.
Corydalis vetusta.

ORTHOPTERA.

Forficularia problematica.
Gryllites dubius.
Phaneroptera Germari.
„ striata.
Chresmoda obscura.
Blattaria Dunckeri.
Locusta prisca.
„ speciosa.
„ amanda.
Blabera invita.
Achita quærula.

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HEMIPTERA.

Velia cornuta.
Naucoris lapidarius.
Corixa mortua.
Belostomum Hartingi.
„ elongatum.
Ricania gigas.
„ hospes.
Lystra Vollenhoveni.
Nepa primordialis.
Propygolampis Bronni.
Pygolampis gigantea.
Actea sphinx.
(Hagenia ?) Schroeteri.
Cicada Proserpina.
„ prisca.
„ gigantea.

DIPTERA.

Asilicus lithophilus.
Musca lithophila.
Tipularia Teyleri.
Empidia Wulpi.
Cheilosia dubia.

HYMENOPTERA.

Apiaria antiqua.
„ lapidea.
„ veterana.
Anomalon palæon.
Bombus? conservatus.

LEPIDOPTERA.

Sphinx Snelleni.[1]
Pseudosirex Darwini.[2]

LIAS.

List of fossil insects from the Lower Marls of the Lias at Schambelen, in the Canton of Aargau, in Switzerland, compiled from Dr. Heer's "Urwelt der Schweiz":—

COLEOPTERA.

	Species.		Species
Carabidæ	... 11	Buprestidæ	... 33
Gyrinidæ	... 6	Elateridæ	... 10
Nitidulidæ	... 7	Telephoridæ	... 3
Peltidæ	... 4	Cistelidæ	... 1
Cryptophagidæ	... 2	Rhynchophora	... 7
Lathridiadæ	... 1	Chrysomelinæ	... 3
Mycetophagidæ	... 1	Doubtful forms	... 6
Byrrhidæ	... 5	Total number of species	
Hydrophilidæ	... 15	of Coleoptera	116
Aphodiidæ	... 1		

ORTHOPTERA.

Blattina formosa.
„ angustata.
„ media.
Gomphocerites Bucklandi.
Acridiites deperditus.
„ liasinus.
Baseopis forficulina.

[1] From the figure of this insect, in Herr Weyenbergh's paper, it undoubtedly belongs to the Sphingidæ.
[2] "Arch. Teyl." t. iii., p. 279, and "Period. Zoo. Arg." t. i., pl. 3.

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NEUROPTERA.

Clathrotermes signatus.
Calotermes maculatus.
„ plagiatus.
Calotermes troglodytes.
„ obtectus.
Æschna Hageni.

HEMIPTERA.

Protocoris insignis.
„ ovalis.
Cyclocoris pinguis, and other species of Coreodea.
Cicadellinæ (3 species.)
Cercopidium morio.
„ minutum.

HYMENOPTERA ? [1]

Palæomyrmex prodromus.

RHÆTICS.

List of fossil insects from Schonen, Sweden [2] :—

COLEOPTERA.

Hydrophilites Nathorsti.
Buprestites rugulosus.
Curculionites parvulus.
„ Carlsoni.
Elytridium angelini.
Elytridium lævigatum.
Carabites deplanatus, and fragments of the abdomen of a beetle.

TRIAS.

From Trebitz, Salzmunde, and Vadutz, Switzerland:—

COLEOPTERA.

Glaphyroptera pterophylli.
Curculionites prodromus.
Chrysomelites Rothenbachi.

NEUROPTERA.

Chauliodites Picteti.
„ Zinckeni.
Chauliodites Helveticus.

ORTHOPTERA.

Legnophora Girardi.

AMERICA. [3]

TRIAS.

From the Triassic Rocks of the Connecticut Valley :—

Coleoptera, one specimen unnamed, and traces of various *Insecta* and *Myriopoda*.

---

[1] No traces of insects of this Order have been elsewhere recorded from rocks of this age, even in those localities in which insect remains have been found in abundance, and it is highly improbable that the Order had appeared at so early a period.

[2] See "Ueber einige Insektenreste aus der raetischen Formation Schonens," Aftryck ur Geol. Föreningens i Stockholm Förhandl., 1878, No. 49 (Bd. iv, No 7), and see *ante*, p. 136.

[3] See *ante*, p. 24.

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From the author

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Three Papers on Fossil Insects, and the British and Foreign Formations in which Insect Remains have been detected.

No. 3.

H. Hagen.

THE INSECT FAUNA.

OF THE

PRIMARY OR PALÆOZOIC PERIOD.

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(Read before the Geologists' Association at University College, on the 7th March, 1879).

BY

H. GOSS, F.L.S.

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THE INSECT FAUNA

OF THE

PRIMARY OR PALÆOZOIC PERIOD,

AND THE

BRITISH AND FOREIGN FORMATIONS OF THAT PERIOD IN WHICH INSECT REMAINS HAVE BEEN DETECTED.

By HERBERT GOSS, F.L.S., F.G.S., &c.

Introduction.

In the Palæozoic rocks of the United Kingdom remains of insects appear to be extremely rare, and the few fragments which have been discovered have all been obtained from the Coal Measures. On the Continents of Europe and America fossil insects have been found more frequently in Palæozoic rocks; but with the exception of the remains of a few specimens from the Permian of Europe, and the Devonian of New Brunswick, North America, all the specimens have been discovered in the Carboniferous rocks.

From the Permian rocks only thirteen fossil insects are known, all of which have been discovered in Saxony. Two of these, from their possessing characters common to two Orders, have been placed by Dr. Goldenberg in an extinct Order, which he has called *Palæodictyoptera*.[1] Two others have been referred to the *Hemiptera*, and the remaining nine to the *Orthoptera*.

From the Carboniferous rocks about 103[2] species of insects have been described. Of these 5 were obtained from the United

[1] See "Fauna Saræpontana Fossilis," Heft 2, 1877.

[2] Inclusive of 10 species of Cockroaches, which have been described by Mr. Scudder since this paper was read in March, 1879.

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Kingdom,[1] about 66 from the Continent[2] of Europe, and 32[3] from North America.[4]

In the Coal Measures remains of the *Neuroptera* (or *Pseudo-Neuroptera*) are comparatively numerous, and in addition to some eleven species, which, (from their possessing characters common both to that Order and the *Orthoptera*,) have been placed by Dr. Goldenberg in the extinct Order[5] before-mentioned, about twenty-four species have been determined.

The *Orthoptera* of this age are represented by more than sixty[6] species, and this Order and the *Neuroptera*—if we include in the last-named those species which have been referred by Goldenberg to the extinct Order *Palæodictyoptera*—comprise all the insects yet discovered from the Carboniferous rocks, except five, two of which have been referred to the *Coleoptera*,[7] and three to the *Hemiptera*.[8] Had the two last-named Orders been thoroughly established, and widely distributed at this Period, their remains would doubtless have been discovered, at least as frequently as those of the *Neuroptera* and *Orthoptera*. It may be inferred, therefore, that at this period the *Neuroptera* and the *Orthoptera* were the dominant Orders, and that towards its close the *Hemiptera* and *Coleoptera* began to make their appearance.

From the Upper Devonian rocks of St. John's, New Brunswick, six species of insects have been discovered, all of which have been described by Mr. Scudder, and referred by him to the *Neuroptera*, or *Pseudo-Neuroptera*. These Devonian rocks of New Brunswick are, according to present discoveries, the oldest in the world in which any traces of insects have been detected.

Before proceeding to enumerate the fossil insects obtained from

[1] Coalbrook Dale, Shropshire; near Sunderland; near Glasgow, &c.

[2] Saarbrück, in the Rhenish Provinces of Prussia; Brücken Waldmohr, Rhenish Bavaria; Manebach, in Saxe Weimar; Wettin and Lobejün, in Prussian Saxony; Klein-Opitz, near Dresden; Erbignon, Valais, Switzerland; Sars-Longchamps, Mons, and elsewhere in the Belgian Coal-fields; Commentry (Allier), France, &c.

[3] Inclusive of the 10 species recently described by Mr. Scudder as before-mentioned.

[4] Sydney, Cape Breton; Picton, Nova Scotia; Cannelton, Beaver County, and Pittston, Pennsylvania; Cassville, Western Virginia; Bellaire and Talmadge, Ohio; Morris, Danville and Colchester, Illinois; Frog Bayou, Arkansas, &c.

[5] *i.e.*, *Palæodictyoptera*. See "Fauna Saræpontana Fossilis," p. 50 (1877).

[6] Inclusive of those recently described by Mr. Scudder as before mentioned.

[7] *Curculioides Ansticii* and *Troxites Germari*.

[8] *Fulgorina Ebersi*, *F. Klieveri*, and *M. Hollebeni*.

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the Palæozoic rocks, I will briefly allude to those Geologists and Zoologists to whom we are chiefly indebted for their discovery, determination, or description.

Amongst the names of the authorities on the fossil *Arthropoda* from the Palæozoic rocks of the United Kingdom, the most prominent is that of Dr. Henry Woodward, F.R.S.[1]; and in connection with the description or determination of the fossil insects of this period, I must also mention the names of Sir Roderick Murchison, F.R.S.,[2] Dr. Mantell, F.R.S.,[3] Dr. Buckland, F.R.S.,[4] Mr. Robert McLachlan, F.R.S.,[5] Mr. J. W. Kirkby,[6] Mr. A. H. Swinton,[7] Mr. J. W. Salter,[8] and Mr. Curtis.

Amongst the Continental authorities on Palæozoic *Insecta* are Dr. Goldenberg,[9] Prof. Germar,[10] Prof. Oswald Heer,[11] Dr. Giebel,[12] Dr. Anton Dohrn,[13] Herr Mahr,[14] Dr. Jordan,

[1] See Dr. Woodward's papers in the "Geol. Magazine," Vol. viii., p. 385, 1871; Vol. ix., 1872; Vol. x. (No. 3), 1873; "Transactions of the Geol. Soc.," Glasgow, Vol. ii., pt. 3, 1867; "The Quarterly Journal of the Geol. Soc.," February, 1876, &c., &c.

[2] "The Silurian System" (pt. 1), pp. 104-105, 1839.

[3] "The Medals of Creation," Vol. ii., p. 552, 1854.

[4] "Bridgewater Treatise," Vol. i., pp. 409-410; and Vol. ii., pp. 75-76, 1836.

[5] See "Compte-Rendu" of the Soc. Ent. Belge., August, 1877; and see "Nature" (No. 496), Vol. xx., pp. 5-6, May, 1879.

[6] "Geol. Magazine," Vol. iv. (No. 39), pp. 388-390, September, 1867.

[7] "Geol. Magazine," Vol. i. (Decade 2), p. 337, 1874.

[8] "Quarterly Journal Geol. Soc." Vol. xix., 1863.

[9] "Sitzungsb. math. nat. Cl. k. Akad. Wiss.," Wien, Bd. ix., pp. 38-39, Wien, 1852; "Ueber versteinerte Insektenreste im Steinkohlengebirge von Saarbrücken," Amtl. Ber. Vers. Gesellsch. deutsch. Naturf., xxix., pp. 123-26, Wiesbaden, 1853; "Die fossilen Insecten des Kohlenformation von Saarbrücken,' in "Palæontographica," Vol. iv., 17-40, 1854; "Beiträge zur vorweltlichen Fauna des Steinkohlengebirges zu Saarbrücken," in the "Jahresbuch. k. Gymn. u. Vorsch. Saarbrück.,' pp. 1-26, 1867; "Neues Jahrbuch für Miner," pp. 158-168, 1869; "Neues Jahrb. für Miner," pp. 286-289, 1870; "Fauna Saræpontana Fossilis," "Die fossilen Thiere aus der Steinkohlenformation von Saarbrücken," Heft 1, 1873, and Heft 2, 1877.

[10] "Beschreibung einiger neuen fossilen Insecten," II. "In Schieferthon des Steinkonlengebirges von Wettin," see Münster's "Beiträge zur Petrefactenkunde," Heft 5, 1842; "Die Versteinerungen des Steinkohlengebirges von Wettin und Lobejün in Saalkreise," Halle 1844-1853.

[11] "Ueber die fossile Kakerlaken," "Vierteljahrschrift d. Naturf. Gesellsch. in Zurich," Vol. ix., 1864; "Die Urwelt der Schweiz," Zurich, 1865; "Le Monde primitive de la Suisse" (French translation by M. Demole), Geneva and Basle, 1872; and "The Primæval World of Switzerand" (English translation by W. S. Dallas, edited by J. Heywood), London, 1876; "Die Urwelt der Schweiz" (2nd edit.), Zurich, 1879.

[12] "Fauna der Vorwelt mit steter Berücksichtigung der lebenden Insecten und Spinnen" (Insecten und Spinnen), Vol. ii., Leipsic, 1856.

[13] "Palæontographica," Vol. xiii., p. 333, 1866; and *op. cit.*, Vol. xvi., p. 129, 1869.

[14] "Neues Jahrbuch für Mineralogie," p. 282, 1870.

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Herr Eugen Geinitz,[1] Dr. Hagen,[2] Dr. H. B. Geinitz,[3] Prof. Pictet,[4] Dr. Fric, Prof. Van Beneden,[5] M. Coemans, M. Audouin,[6] M. Alfred Preudhomme de Borre,[7] and M. Charles Brongniart.[8]

For our knowledge of the fossil insects of the Palæozoic rocks of North America we are indebted chiefly to Mr. Scudder,[9] and also to Dr. Dawson,[10] Professor Dana,[11] Professor Leo Lesquereux,[12] Mr. Harger, Mr. C. F. Hartt, Mr. F. B. Meek, Mr. A. H. Worthen, Dr. Newberry, Mr. James Barnes, Mr. J. G. Bronson, Mr. R. D. Lacoe, Mr. R. Brown, and Mr. J. F. Mansfield.

I will now proceed to enumerate the fossil insects which have been described from the Primary rocks. After having done this, I shall briefly review the facts which have been brought under notice in this and the two preceding papers, and shall endeavour to suggest a few deductions which may be drawn therefrom.

[1] "Neues Jahrbuch für Min.," pp. 691-704, 1873; "Neues Jahrbuch für Min.," pp. 1-14, 1875.

[2] "Linnaea Entomologica," Zeitschrift von dem Entomologischen Vereine in Stettin," Band 10, p. 302, 1855.

[3] "Sitzungsb. naturw. Gesellsch. Isis," pp. 7-13, Dresden, 1879.

[4] "Traité élementaire de Paléontologie," Geneva, 1846, and Paris, 1854.

[5] "Bull. Acad. Royale de Belgique," 2me Serie, T. xxiii., No. 4, 1867.

[6] "Ann. Soc. Ent. France," Vol. ii., Bull., pp. 7-8, 1833.

[7] "Notes sur des empreintes d'insectes fossiles," "Ann. Soc. Ent. Belgique," T. xviii., 1875.

[8] "Ann. Soc. Ent. France," vme Serie, 1876; "Comptes-Rendu Soc. Ent. Belge," pp. 9-12, January, 1878; and "Ann. des Sciences Naturelles," 6me Serie, Tome 7 Art. No. 4, 1879.

[9] See Dawson's "Acadian Geology," 2nd edit., p. 388, London, 1868; "The Geological Survey of Illinois" (Worthen), Vol. iii., pp. 566-572, 1868; "Canadian Naturalist" (N.S.), Vol. vii., pp. 271-272, Montreal, 1874; "Proc. Amer. Assoc. adv. Science," Vol. xxiv., pp. 110-111, Salem, 1876; "Canad. Nat." (N.S.), Vol. viii., pp. 88-90, Montreal, 1876; "Geol. Mag." (N.S.), Vol. iii., pp. 519-520, London, 1876; "Proc. Bost. Soc. Nat. Hist.," Vol. xix., pp. 238-239, Boston, 1878; "The Early Types of Insects," Bost. Soc. Nat. Hist., Vol. iii. Part 1, No. 2, Boston, March, 1879; "Palæozoic Cockroaches," Memoirs of the Bost. Soc. Nat. Hist, Vol. iii., pt. 1, No. 3, pp. 23-134, Boston, November, 1879.

[10] "Quart. Journal Geol. Soc., Lond.," Vol. xvi., p. 268; "Geol. Mag.," Vol. iv., No. 9, 1867; and "Acadian Geology," 1868.

[11] "Sill. Journ." (2), Vol. xxxvii., pp. 34-35, 1864.

[12] Owen's 2nd "Report Geol. Arkansas," pp. 295-399, 1860.

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GREAT BRITAIN.

CARBONIFEROUS.

Of the five fossil insects obtained from the British Coal-measures, four have been referred to the *Orthoptera*, and one to the *Coleoptera*. The representative of the last-named order is the oldest British fossil insect known. It was discovered in the Iron-stone of Coalbrook Dale, Shropshire, and was described by Dr. Buckland[1] as *Curculioides Ansticii*.[2]

The first discovered species of *Orthoptera* from the British Carboniferous rocks was also obtained from the Ironstone of Coalbrook Dale. Sir Roderick Murchison[3] observes of this fossil:—"It was supposed to be a plant, and was sent to Adolphe Brongniart, who immediately perceived that the transverse nervures were unlike anything in the vegetable kingdom, and on being referred to M. Audouin, it was pronounced to be the wing of a *Neuropterous* insect, resembling the living *Corydalis* of Carolina and Pennsylvania." It was subsequently described by Dr. Mantell[4] as belonging to the genus *Corydalis* of the *Neuroptera*, and was named by him *Corydalis Brongniarti*. Mr. Swinton has since referred this insect to the genus *Gryllacris* of the *Orthoptera*.[5]

In addition to these fossils, three fragments of *Orthoptera* were discovered, some years ago, in the Durham Coal-fields.[6] One of the fragments is described by Mr. Kirkby as being a very fine distinct example of the anterior portion of the fore wing of an insect, in form and neuration agreeing with the genus *Blatta*, but

[1] "Bridgewater Treatise," Vol. ii., *antea cit.*, p. 76; see also the "Geol. Trans." (2nd series), Vol. v., pt. 3, p. 446; and "The Silurian System," *antea cit.*, pp. 104–105.

[2] Dr. Buckland describes two insects from Coalbrook Dale as *Curculionidæ*, *i.e.*, *C. Ansticii* (above-mentioned) and *C. Prestvicii*; but Dr. H. Woodward, has decided that the last-named fossil should have been referred to the *Arachnida* and not to the *Insecta*. See "Geol. Mag.," Vol. viii., p. 385, September, 1871.

[3] "The Silurian System" (pt. 1), *antea cit.*, pp. 104-105.

[4] "Medals of Creation," Vol. ii., p. 552, 1854.

[5] See a paper by Mr. A. H. Swinton in "Geol. Mag.," p. 337, pl. xiv., August, 1874.

[6] The locality was the North bank of the Wear, opposite to Claxheux, about two miles west of Sunderland. See Mr. Kirkby's paper in the "Geol. Mag.," Vol. iv., p. 388, 1867.

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approaching the *Mantidæ*.[1] The third[2] specimen is believed, from its shape and neuration, to be the abortive anterior wing of some species belonging to the *Phasmidæ*, but it is impossible to pronounce with any certainty as to its probable affinities.

The most recently discovered fossil insect from British strata of this period was found in a clay-ironstone nodule obtained from the Scottish Coal-fields. It has been referred[3] by Dr. Henry Woodward to the *Mantidæ*, and has been named by him *Lithomantis carbonarius*.

CONTINENT OF EUROPE.

PERMIAN.

The Permian rocks are extensively developed in Russia and Germany, and they also occur in some parts of Great Britain and North America; but from their comparatively limited geographical and superficial range, the number of fossils obtained from them is proportionately small, and of the *Insecta* only about thirteen species have been discovered, all of which were found in that part of Germany[4] which has been styled by Lyell[5] "the classic ground" of this formation on the Continent.

One of the first discovered and most interesting of these insects, was obtained from an Ironstone pit, belonging to Herr Böcking, at Schwarzenbach in the district of Birkenfeld, and was described in 1866 by Dr. Anton Dohrn,[6] who named it *Eugereon Böckingi*.[7] Dr. Dohrn states that Herr Tischbein and Dr. Hagen

[1] Dr. Goldenberg has included this insect in his list of fossil *Blattidæ*, under the name of *Blattidium mantidioides*. (See "Fauna Sar. Fossilis," pt. 2, p. 20, 1877).

[2] The second specimen appears to be a part of the same insect as No. 1.

[3] "Quart. Journal Geol. Soc.," February, 1876, p. 60. In deciding as to the family to which this fossil belonged, Dr. Woodward states that he had the advantage of the opinions of Mr. Mc Lachlan, Prof. Westwood, and Mr. C. O. Waterhouse.

[4] Schwarzenbach, near Birkenfeld Cassel, and Weissig, near Pillnitz, in Saxony.

[5] "Elements of Geology," 6 edit., p. 460.

[6] "Palæontographica," Vol. xiii., p. 333, 1866.

[7] For a description of this fossil, see "Palæontographica," last *cit.*; and also Vol. xvi., p. 129, 1869; the "Stettiner Ent. Zeitung," xxviii., 1867; and Goldenberg's "Fauna," pt. 2, *antea cit.*, pp. 11-14, 1877.

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both regarded this insect as an *Hemipteron*, and he adds that he was originally of the same opinion himself, but that after a further examination of this remarkable fossil, he decided that it could not be referred to any existing Order, as it combined characters both of the *Neuroptera* [1] and *Hemiptera*.

Dr. Dohrn does not, of course, regard *Eugereon* as a type of the common ancestor or progenitor of the *Neuroptera* and *Hemiptera*, as both these Orders were already in existence; but he is of opinion, that at a very remote period a form existed, completely intermediate between these two Orders, from which they were differentiated, and from which *Eugereon* was also descended.

As this insect could not be referred to any existing Order, it was placed by its describer in a new Order, which he created for it, and which he named *Dictyoptera*; it has recently been included by Dr. Goldenberg [2] in his Order *Palæodictyoptera*.

Another fossil, scarcely less interesting than *Eugereon*, discovered by Herr Karl Rückert in the neighbourhood of Stockheim, in Bavaria, was described in 1865 by Dr. H. B. Geinitz,[3] who named it *Ephemerites Rückerti*. From its union of characters of the genera *Ephemera* and *Libellula*, Dr. Goldenberg has recently placed this fossil in his Order *Palæodictyoptera*.

A fragment of a wing, obtained from Weissig, near Pillnitz, in Saxony, has been referred by Herr Eugen Geinitz [4] to a species of *Hemiptera—Fulgorina Klieveri*—a specimen of which has been also obtained [5] from the European Coal Measures; but Dr. Goldenberg has recently informed [6] me that he is not aware of any specimen of the last-named species (*F. Klieveri*) having been discovered in Permian strata; but that two other species belonging to the genus *Fulgorina*, viz., *F. Ebersi* and *F. lebachensis*, have been obtained from the Permian.

The nine other insects discovered in strata of this age all belong

[1] All the synthetic types hereinafter alluded to exhibit a union of the characters of *Neuroptera* and *Orthoptera*, or *Neuroptera* and *Pseudo-Neuroptera*.

[2] "Fauna Sar. Foss.," pt. 2 (1877), *antea cit.*, p. 50.

[3] "Neues Jahrb. für Min.," pp. 385-388, 1865.

[4] See "Neues Jahrb. für Min.," pp. 6 and 12, and plate 1, fig. 3, p. 112, 1875.

[5] Described by Dr. Goldenberg in "Neues Jahrb. für Min.," p. 166, 1869.

[6] In a letter dated 12th January, 1879.

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to the extinct genus *Blattina*[1] of the family *Blattidæ* of the *Orthoptera*, and the majority of them were obtained from Weissig. Of these *Blattidæ*, five species—*Blattina Weissigensis*,[2] *B. porrecta*,[3] *B. Rückerti*, *B. lebachensis*, and *B. gracilis*—have only been discovered in Permian strata, but specimens of the remaining four, viz., *B. didyma* (*sopita*), *B. anthracophila* (*flabellata*), *B. carbonaria*, and *B. Mahri* (*elongata*) have been also obtained from the European Coal Measures.

The specimen of *Blattina didyma*[4] (*sopita*) from the Permian appears, for an insect of such vast antiquity, to be in an unusually perfect state of preservation, the body, wings, and legs being almost entire; but the other *Blattidæ* are represented only by single wings, or parts of wings.

CARBONIFEROUS.

The principal localities on the Continent of Europe in which fossil insects have been discovered in the Carboniferous rocks, are Saarbrück, in the Rhenish provinces of Prussia; Brücken, Waldmohr, Rhenish Bavaria; Manebach, in Saxe Weimar; Wettin and Löbejün, in Prussian Saxony; Klein-Opitz, near Dresden; Erbignon Valais, Switzerland; Sars-Longchamps, and Mons, Belgium; and Commentry (Allier), France.

Of *Neuropteroid* insects about sixteen species have been obtained from the neighbourhood of Saarbrück, nine[5] of which have been referred by Dr. Goldenberg[6] to an extinct genus—*Dictyoneura*—and have recently been placed by him in the extinct Order *Palæodictyoptera*. The remaining seven species are representatives of the family *Termitidæ*, viz., *Termes Heeri*, *T. affinis*, *T. Hageni*, *T. Buchi*, *T. laxa*, and *Termitidium amissum*, and *rugosum*.

About fourteen years ago M. Coemans discovered at Sars-Longchamps, in the Belgian Coal-fields, the wing of an insect in a

[1] Mr. Scudder has recently distributed these Permian *Blattidæ* amongst his new genera—*Etoblattina*, *Anthracoblattina*, *Hermatoblattina*, and *Petrablattina*.

[2] Described by Herr Eugen Geinitz, in "Neues Jahrb. für Min.," pp. 692-694, 1873.

[3] Eug. Geinitz in "N. Jahrb. für Min.," p. 6, 1875.

[4] See "N. Jahrb. für Min.," 1875, *antea cit.*, plate 1, fig. 1, p. 112.

[5] *Dictyoneura libelluloides*, *anthracophila*, *formosa*, *Decheni*, *elegans*, *elongata*, *Schmitzii*, *obsoleta*, and *Humboldtiana*.

[6] "Fauna Saræpontana Fossilis," *antea cit.*, 1873 and 1877. See also "Palæontographica," Vol. iv., 1854.

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tolerably perfect state of preservation, which was referred by him and Prof. Van Beneden to an extinct genus of *Neuroptera*. This fossil was subsequently described[1] by them as *Omalia macroptera*, and it has since been included by Dr. Goldenberg[2] in his Order *Palæodictyoptera*.

In 1874 three specimens, or rather fragments, of insects were discovered by M. Persinaire and M. Crepin, in the Mons basin of the Belgium Coal-fields, and were subsequently described by M. Alfred Preudhomme de Borre.[3] One of the fragments was *supposed* to be part of the wing of a species of *Termes*, but it was in far too imperfect a state to admit of its determination.

The most perfectly preserved wing of the three[4] was originally described by M. de Borre as belonging to the *Orthoptera*, and was named by him *Pachytylopsis Borinensis*[5]; but after Dr. Breyer had examined it, and expressed an opinion that it belonged to the *Lepidoptera*, its name was changed to *Breyeria Borinensis*. This fossil was subsequently submitted to Mr. McLachlan,[6] in Brussels, in August, 1877, and he decided, after a careful examination of the wing, in which he detected abundant traces of transversal reticulation, that it could not have belonged to the *Lepidoptera*,[7] and that it was the wing of a *Neuropterous* insect of the family *Ephemeridæ*.

The fossil *Orthoptera* from the European Coal Measures belong, with few exceptions, to the *Blattidæ*, of which family about thirty-six species have been described by Germar, Goldenberg, Giebel, Heer, H. B. Geinitz, E. Geinitz, Dohrn, and Mahr, viz., *Blattina primæva*,[8] *labachensis*, *insignis*, *winteriana*, *intermedia*, *scaberata*,

[1] "Bull. Acad. Royale Belgique," 2nd Series, Tome xxiii., pp. 384-401, 1867.

[2] "Fauna Sar. Fos.," Heft 2, *antea cit.*, 1877.

[3] "Notes sur des empreintes d'insectes fossiles." "Ann. Soc. Ent. Belgique," Tome xviii., 1875.

[4] For the name of the second specimen belonging to the family *Acridiidæ* of the *Orthoptera*, see next page.

[5] "Bull. Acad. Royale Belgique," *antea cit.*

[6] "Compte-Rendu Soc. Ent. Belgique," August, 1877, *antea cit.*; and "Nature" (No. 496), Vol. xx., pp. 5-6, May, 1879.

[7] Mr. Alfred Russel Wallace believes the wing to be *Lepidopterous*. See "Nature" (No. 495), Vol. xix., p. 582, April, 1879.

[8] Since this paper was read in March, 1879, Mr. Scudder has re-described all the known species of fossil cockroaches from Europe and America in a very long and elaborate paper, published in the "Memoirs of the Boston Society of Natural History" (Vol. iii., pt. 1, No. 3, *antea cit.*). With the exceptions of *Tischbeini*, *latinervis*, and *granosus*, the two first of which are still referred to the genus *Blattina*, and the last named to the genus *Poly-*

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wemmetsweilerіensis, *Tischbeini*, and *Polyzosterites granosus* from the neighbourhood of Saarbrück; *B. Remigii* and *weissiana*, from Cusel and Brücken respectively; *B. didyma*, *Manebachensis*, *Goldenbergi*, *latinervis*, *clathrata*, *Mahri*, and *Fritschii*, from Manebach; *B. euglyptica*, *affinis*, *flabellata*, *anthracophila*, *Dohrnii*, *anaglyptica*, *carbonaria*, *russoma*, *leptophlebica*, *parvula*, *spectabilis*, *Geinitzi*, *Münsteri*, *producta*, *Germari*, and *reticulata*, from Wettin and Löbejün; *B. Dresdensis*, from Klein-Opitz, near Dresden; and *B. Helvetica*, from Erbignon Valais, which according to Professor Heer [1] is the most ancient Swiss fossil animal known.

The other *Orthoptera* from the European Coal Measures include *Gryllacris lithanthraca* [2] and *Acridites formosus* [3] from the neighbourhood of Saarbrück; *Pachytylopsis Persenairei* [4] from the Belgian Coal-fields; and one species of *Phasmidæ* from the Upper Coal Measures of Commentry, which has been described by M. Charles Brongniart [5] and named by him *Protophasma Dumasii*. M. Brongniart observes of this species that it approaches *Phasma variegatum* in its neuration.

The only representatives of the *Hemiptera* from the Carboniferous rocks are *Fulgorina* (*Fulgora*) *Ebersi* [6] and *Klieveri* [7] from Saarbrück, and *Macrophlebium Hollebeni* [8] from Mannebach.

The *Coleoptera* are represented by one specimen—*Troxites Germari* [9]—from Saarbrück, and by traces of borings in petrified wood from the Carboniferous Limestone of Autun, which are believed by M. Charles Brongniart [10] to have been made by a species

zosterites, all the species have been distributed by Mr. Scudder amongst new genera created by him, viz., *Etoblattina*, *Gerablattina*, *Anthracoblattina*, *Progonablattina*, *Petrablattina*, *Oryctoblattina*, and *Hermatoblattina*.

[1] "Viertelj. Naturf. Gesellsch. Zürich," ix., 287, 291-293, 1864; "Die Urwelt der Schweiz.," 1st edit. (529, Note), 1865; and 2nd edit. p. 24, Zürich, 1879.

[2] "Palæontographica," Vol. iv., 1854; "Fauna Saræpontana Fossilis," Heft 1, p. 20, 1873.

[3] *Op.* last cited, pp. 18-19.

[4] "Ann. Soc. Ent. Belgique," Tome xviii., 1875 (*antea cit.*).

[5] "Compte-Rendu. Soc. Ent. Belgique," Serie 11, No. 47 (pp. 9-12), January, 1878; and "Annales des Sciences Naturelles," 6me Serie, Tome 7, 2-4, Article No. 4, 1878.

[6] "Palæontographica," Vol. xvi., 1869; "Fauna Sar. Foss.," Heft 2, pp. 28 30, 1877.

[7] "Neues Jahrbuch für Min.," 1869; Fauna Sar. Foss," Heft 2, p. 31, 1877.

[8] "Neues Jahrb. für Min.," pp. 158-168, 1869.

[9] "Palæontographica," Vol. iv., 1854; and "Fauna Sar. Foss.," Heft 1, p. 7, 1873.

[10] "Annales Soc. Ent. France," Vme Series, 1876.

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of *Hylesinus*. Dr. Geinitz has also referred similar borings in fossil wood, in the Coal Measures of Saxony, to a beetle which has been named by Dr. Fric *Xyloryctes planus*.

AMERICA.

CARBONIFEROUS.

The fossil insects obtained from the American Carboniferous rocks all belong to the *Neuroptera* and *Orthoptera*.

The *Neuroptera* are represented by thirteen species, viz., *Miamia Bronsoni*[1] and *Danæ*,[2] *Crestotes lapidea*,[3] *Hemeristia occidentalis*,[4] *Megathentomum pustulatum*,[5] *Euephemerites simplex*,[6] *gigas*,[6] *affinis*,[6] and *primordialis*,[7] *Libellula (?) carbonaria*,[8] *Haplophlebium Barnesii*,[9] *Paolia vetusta*,[10] and *Termes contusus*[11].

From the neuration of the wings of the species respectively belonging to the genera *Miamia* and *Hemeristia*, Mr. Scudder is of opinion that each represents a new family of *Neuroptera*, containing peculiarities, both of *Neuroptera* proper and *Pseudo-Neuroptera*. The species belonging to the genus *Termes* (*T. contusus*) is especially interesting as being, I believe, the only fossil specimen of a white ant discovered in America. Amongst the remains referred by Scudder to the genus *Euephemerites* is "the well[12] defined wing of an insect of marked simplicity" (*E. primordialis*). Mr. Scudder observes that in this ancient wing scarcely the slightest differentiation has begun. In this respect, therefore, this wing differs from all others yet discovered; for even in

[1] "Silliman's Journal" (2), Vol. xxxvii., p. 34.
[2] "Geol. Illinois," Vol. iii., p. 566.
[3] *Op.* last cited, Vol. iii., p. 567.
[4] "Sill. Jourl." (2), Vol. xxxvii., p. 34.
[5] "Geol. Ill.," Vol. iii., p. 570.
[6] *Op.* last cited, pp. 472 and 571.
[7] "Proc. Bost. Soc. Nat. Hist.," Vol. xix., p. 37, 1878.
[8] "Proc. Amer. Assoc. Adv. of Science," Vol. xxiv., p. 110; and see "Geol. Mag." (No. 149), Vol. iii., N.S., p. 519, 1876.
[9] Dawson's "Acadian Geology," p. 387, 1868; and "Geol. Magazine" (No. 39), Vol. iv., p. 386, 1867.
[10] "Silliman's Jour." (3).
[11] "Proc. Bost. Soc. Nat. Hist.," Vol. xix., p. 54, 1878.
[12] Proc. last cited, p. 37.

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those obtained from the Devonian rocks, the differentiation of the wings is scarcely less perfect than in living insects.

The fossil referred to the genus *Libellula* is supposed to be the abdomen of a larval Dragon-fly; but it appears to me to be so imperfect and fragmentary, that it is impossible to say to what insect it belonged. It is extremely improbable that this fossil should have belonged to the *Odonata*, which, although abundantly represented in the Jurassic rocks of Solenhofen, and also—though less commonly—in the English Lias, are unknown in rocks of greater antiquity.

The fossil named *Haplophlebium Barnesii*[1] appears to have belonged to the *Ephemeridæ*, and consists of a long narrow[2] wing, about three and a-half inches in length, so that the insect, when expanded, must have measured over seven inches, and have been much larger than any living species of that family. Mr. Scudder says of it—"The extreme simplicity of the neuration probably "places this insect among the *Ephemerina*, although the form of the "wing and the reticulation recall the *Odonata*; other features of "the wing resemble the *Odonata*, and it is not impossible that "*Haplophlebium* forms a synthetic type, combining essential "characters of *Odonata*[3] and *Ephemerina*."

In alluding to the family (*Ephemeridæ*) to which this gigantic species has been referred, Dr. Dawson observes—"When we con- "sider that the larvæ of such creatures inhabit the water, and "delight in muddy bottoms, rich in vegetable matter, we can easily "understand that the swamps and creeks of Carboniferous Acadia "must have been especially favourable to such creatures, and we can "imagine the larvæ swarming on the deep black mud of the ponds "in these swamps, and furnishing a great part of the food of the "fishes inhabiting them, while the perfect insects emerging from the "waters, to enjoy their brief space of aërial life, would flit in millions "over the quiet pools and through the dense thickets of the Coal "swamps."[4]

[1] Dr. Goldenberg has placed this fossil in the extinct order *Palæodictyoptera* before referred to. "Fauna Sar. Foss.," Heft 2, 1877.

[2] See plate xvii., fig. 1, 391, "Geol. Mag.," September, 1867. See also "A Manual of Palæontology," by Prof. Alleyne Nicholson, M.D., p. 186, fig. 129; and Dawson's "Acadian Geology," p. 387, 1868.

[3] Dr. Dawson is of the same opinion. See "Geol. Mag." (No. 39), Vol. iv., p. 386, 1867.

[4] "Geol. Mag." (No. 39), Vol. iv., p. 386 (*antea cit.*).

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With the exception of a cricket—*Archegogryllus priscus*[1]—and a supposed species of *Mantis*,[2] all the *Orthoptera* from the Carboniferous rocks of America (amounting to nineteen in number) belong to the *Blattidæ*[3] (Cockroaches), viz., *Blattina venusta*,[4] *Heeri*,[5] *Bretonense*,[6] *sepulta*,[7] and *fascigera*,[8] *Mylacris anthracophilum*,[9] *Pennsylvanicum*,[10] and *Mansfieldi*,[11] *Archymylacris acadicum*,[12] and *parellelum*,[13] *Necymylacris heros*,[13] and *lacoanum*,[13] *Lithomylacris angustum*,[13] *pittstonianum*[13] and *simplex*, *Gerablattina balteata*,[13] and *Etoblattina Lesquereuxii*.[13]

These seventeen species of Cockroaches have been arranged by Mr. Scudder[14] in two groups—*Mylacridæ* and *Blattinariæ*—in the first of which he has placed *Bretonense*, *Heeri*, *Pennsylvanicum*, *Mansfieldi*, *heros*, *angustum*, *Pittstonianum*, *lacoanum*, *simplex*, and *anthracophilum*; and in the second *sepulta*, *acadicum*, *parallelum*, *Lesquereuxii*, *fascigera*, *balteata*, and *venusta*. With the exceptions of *venusta*, *Heros*, *parallelum*, *fascigera* and *sepulta*, which were obtained from the Millstone Grit,[15] all the other specimens were discovered in the Coal Measures.

[1] "Proc. Bost. Soc. Nat. Hist.," Vol. xi., p. 402.

[2] "Geol. Ill.," Vol. iii., p. 567.

[3] Mr. Scudder has recently divided this family into two groups—*Mylacridæ* and *Blattinariæ*. See "Mem. Bost. Soc. Nat. Hist.," Vol. iii., pt 1, No. 3, November, 1879, *antea cit.*

[4] "Owen's 2nd Rep. Geol. Arkansas," p. 314.

[5] "Can. Nat." (N.S.), Vol. vii., p. 272.

[6] *Op.* last cited, p. 271.

[7] "Proc. Amer. Assoc. Adv. Science," Vol. xxiv., p. 111.

[8] "Proc. Bost. Soc. Nat. Hist.," xix., pp. 238-239.

[9] "Geol. Ill.," Vol. iii., p. 568.

[10] "Mem. Bost. Soc. Nat. Hist.," Vol. iii., pt. 1, No. 3, 1879.

[11] *Op.* last cited.

[12] "Acadian Geology," p. 388, 1868; and "Mem. Bost. Soc. Nat. Hist.," Vol. iii., pt. 1, No 3, *antea cit.*

[13] *Op.* last cited. With the exception of *B. venusta*, *Heeri*, *Bretonense*, *sepulta*, and *fascigera*, *Mylacris anthracophilum*, and *Archimylacris acadicum*, all these *Blattidæ* have been described by Mr. Scudder in the "Mem. Bost. Soc. Nat Hist.," Vol. iii., pt 1, No. 3 *antea cit.* since the date at which this paper was read.

[14] "Proc. Bost. Soc. Nat. Hist.," Vol. iii., pt. 1, No. 3 *antéa cit.*

[15] Op. last cited, p. 36.

NOTE.—All the species described or re-described in the work last mentioned have been referred to genera which, with the exceptions of *Mylacris* and *Archymylacris*, were previously uncreated.

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DEVONIAN.

The six oldest known fossil insects were obtained by Mr. C. F. Hartt, from the Devonian rocks of New Brunswick. The locality in which they were found has been named by their discoverer "Fern Ledges," and is situated about a mile west of the town of Carleton, near St. John's. The rocks at this place are described as forming a series of ledges exposed on the sea shore between high and low water mark, and consisting of sandstone and fossiliferous shales rich in plant remains. Some doubt as to the age of these rocks has been expressed by Dr. Geinitz,[1] who considered them as probably belonging to the Carboniferous formation from the fact that one of the insects obtained from them was associated with a fern characteristic of that formation; but Dr. Dawson[2] believes that from their containing beds richly stored with Devonian plants, and underlying unconformably the oldest portion of the Carboniferous series, they belong most unquestionably to the Devonian formation, and his opinion has been accepted by all the leading geologists in Europe and America.

As these Devonian insects are the most ancient representatives of their Class yet discovered, they are especially interesting, and are probably worthy of a more detailed notice than has been bestowed in these papers on the majority of those obtained from more modern rocks. They have all been described[3] by Mr. Scudder, and respectively named by him *Xenoneura antiquorum*, *Gerephemera simplex*, *Platephemera antiqua*, *Lithentomum Harttii*, *Dyscritus vetustus*, and *Homothetus fossilis*.

Xenoneura antiquorum and *Gerephemera simplex* were obtained from a lower portion of the shales than any of the others, and are therefore, presumably, the oldest of the six. The first-named fossil, *X. antiquorum*, appears to be the basal portion of a small wing, which was probably about two inches in expanse. From the peculiar nature of its neuration Mr. Scudder is of opinion that it represents an extinct family of *Neuroptera*, and probably belonged

[1] "Sitzungsb. der Naturf. Gesellsch." Isis, Dresden, 1866.

[2] "Geol. Mag.," Vol. iv., p. 386, 1867.

[3] See Bailey's "Observations on the Geology of Southern New Brunswick," Appendix A., pp. 131-141, 1865; "Geol. Mag.," Vol. v., pp. 175-176; Vol. iv., pp. 387-388; "Acadian Geol.," *antea cit.*, p 525; and Dana's "Manual," *antea cit.*, p. 273-274.

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to a group constituting a synthetic type between the *Orthoptera* and *Neuroptera*. He observes that the most striking peculiarity in this specimen is the development of apparently independent veinlets, forming portions of concentric rings, at the base of the wings, which he compared to the stridulating organ of some male saltatorial *Orthopteron*. Dr. Dawson,[1] in alluding to this peculiarity in this specimen, remarks that "nothing is more curious than the "apparent existence of a stridulating or musical apparatus, like that "of the cricket, in an insect otherwise allied to the *Neuroptera*. "This structure also," continues Dr. Dawson, "if rightly inter-"preted by Mr. Scudder, introduces us to the sounds of the Devonian "woods, bringing before our imagination the trill and hum of insect "life that enlivened the solitudes of these strange old forests."[2]

The second specimen, *G. simplex*, consists of a fragment of the tip of a large broad wing, which appears to have belonged to a member of the *Ephemerina*.

The third specimen, *P. antiqua*, is believed to be a portion of the upper wing of a gigantic species of the *Ephemerina*, which must have measured five inches in expanse of wings, and from its combination of peculiarities[3] of structure now only found in different groups must also be regarded as a "synthetic type."

The fourth specimen, *L. Harttii*, is supposed to be a portion of the lower wing of a *Neuropterous* insect, measuring about three and a-half inches in expanse of wings, and allied to the *Sialina*, but not belonging to any family represented among existing forms.

The fifth specimen, *D. vetustus*, is represented by so small a fragment of a wing that Mr. Scudder considers it impossible to determine the approximate size of the insect, or the family to which it belonged, though its characters are clear enough to show it was *Neuropterous*, and to distinguish it with certainty from the other specimens.

The last specimen, *H. fossilis*, consists of the greater portion of the upper wing of an insect, which Mr. Scudder believes to be the representative of another new family of *Neuroptera*, "synthetic in nature, combining features of the *Odonata* and *Sialina*;" and he

[1] See plate xvii., "Geol. Mag.," Vol. iv., p 390.

[2] "Geol. Mag.," Vol. iv., p. 387, 1867; and "Acadian Geology," pp. 524-525, *antea cit.*

[3] Mr. Scudder observes of this specimen—"The intercalary nervules which in *Ephemerina* generally originate independently, arise here from a bent cross-vein much as in *Odonata*." "Geol. Mag," Vol. v., p. 175, 1868.

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adds that though it is in a mutilated condition the extent and character of every principal nervure can be determined.

The most noticeable peculiarity of this specimen appears to be a heavy cross vein near the base of the wing—between the principal middle nervures—and from which cross vein new prominent veins take their rise.

Although these Devonian insects are the oldest specimens yet discovered, the families to which they belonged had doubtless existed for ages; and it must not be assumed that even their family types necessarily, or even probably, represented the earliest forms of insect life. In all other classes of the Animal Kingdom, with whose fossil remains we are acquainted, as well as in the Vegetable Kingdom, the simpler forms precede the more highly organised. There seems no reason for supposing that the *Insecta* formed any exception to this rule, and we may fairly assume that the earliest types of this class were likely to have been larger in size, simpler in form, and less specialized than these remarkable *Neuropteroid* insects of the Upper Devonian period; and that they had probably existed for ages before that epoch, as had representatives of the *Crustacea*, the *Mollusca*, and even the *Vertebrata*.[1]

Reasoning from the analogy which one may assume to exist between the *Insecta* and other Classes of the Animal Kingdom in progressive development, it seems highly probable that further researches in earlier Devonian strata, and possibly in rocks of even greater age (Silurian), may bring to light more ancient forms of insect life than any yet discovered.

The appearance of insects on the Earth was probably synchronous with that of land plants,[2] and as remains of this division of the Vegetable Kingdom have been discovered in rocks belonging to the Upper Silurian[3] period, the existence of a land flora, ages before the date at which these Devonian insects lived, is proved. The fact of the existence of land plants[4] at as early a date as the

[1] The oldest known type of fishes is described by J. W. Salter, F.G.S. in the "Annals and Mag. of Nat. Hist.," Vol. iv., 1859.

[2] It is not impossible, however, that insects may have appeared before land plants, which were not absolutely necessary to the existence of groups similar in their nature to the *Odonata* and *Ephemerina*, which are essentially carnivorous and aquatic in their early stages.

[3] Dana's "Manual of Geology," *antea cit.*, p. 245; and "The Origin of the World," by Dr. Dawson, F.R.S., p. 330, London, 1877.

[4] "In the Upper Ludlow beds (Silurian Period) occur seed vessels called *Pachytheca* by Hooker, and also fragments of stems supposed to be

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close of the Silurian period appears to me to be an additional reason to those previously given for assuming the probability of the first appearance of insects at a much earlier age than that of the Devonian shales at "Fern Ledges."

I have, I believe, enumerated all the known fossil insects which have been obtained from the Palæozoic rocks of the United Kingdom, and the Continents of Europe and America.

The 122 species which have been named and described are Geographically distributed as follows :—

From the United Kingdom[1] . .	5
,, Continent of Europe .	79
,, ,, America .	38
Total .	122

The Geological distribution of these fossils is as follows :—

From the Permian . . .	13
,, Carboniferous . . .	103
,, Devonian . . .	6
Total . .	122

CONCLUSION.

Having in this and the two[2] preceding papers called attention to those formations of the Post Tertiary, Tertiary, Secondary, and Primary Periods, from which insects have been obtained, and having enumerated the Orders, Families, Genera, and, in many cases, the species to which these fossils have been referred, I propose to offer a few suggestions, as to some of the conclusions which may be arrived at, from a consideration of the facts which have been adduced.

those of *Lycopods* (ground pines). In Germany, at Lobenstein, and at Hostin in Bohemia, *Lycopods* of the *Lepidodendron* family occur. . . . . Besides these flowerless species (Cryptogams), others of genera of the pine tribe—the lowest division of flowering plants (Phenogams)—are supposed by Dawson to have existed, and he has referred pieces of carbonised wood from the Upper Ludlow beds to the genus *Proto-taxites*" (*πρῶτος* first, and *taxus* yew tree). Dana's "Manual of Geology," *antea cit.*, p. 245.

[1] There are, I believe, several species in the collections of the Rev. P. B. Brodie and others which have not yet been described.

[2] See "Proc. Geol. Assoc.," Vol. v. (No. 6), pp. 282, 343, April 1878; and Vol. vi. (No. 3), pp., 116-150, July 1879.

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Let us consider (firstly) what information is afforded by Palæontology on the questions of the origin and progressive development of insects; the order of the apparition of the various groups on the Geological horizon; the antiquity of many of their existing genera; and (secondly) what inferences may be drawn as to the land and fresh water conditions of the Earth, of its climate and vegetation in any former Period, and of the contemporaneous existence of other Classes of the Animal Kingdom from a study of the fossil insects of such Period.

Before proceeding to show what evidence has as yet been furnished by Palæontology, in support of the opinions of many Biologists, as to the evolution or gradual progression of the existing Orders of Insects from some primitive type, it will be necessary to refer briefly, to the writings on this subject of Prof. Haeckel, Dr. Fritz Müller, and Sir John Lubbock.

Prof. Haeckel and many other Biologists are of opinion that the *Crustacea*, *Myriopoda*, *Arachnida*, and *Insecta*, must have had a common ancestor, from which the *Crustacea* first, and through it, the other Classes of the *Arthropoda* are descended.

Dr. Fritz Müller[1] is of opinion that the water-inhabiting and water-breathing *Crustacea*, must be regarded as the original stem, from which the other terrestrial Classes of the *Arthropoda*, with their tracheal respiration, have branched off.

Sir John Lubbock,[2] writing on the origin and metamorphoses of Insects, observes—"there are good grounds for considering "that the various types of insects are descended from ancestors "more or less resembling the genus *Campodea*,[3] with a body divided "into head, thorax, and abdomen; the head provided with mouth "parts, eyes and one pair of antennæ; the thorax with three pairs of "legs; and the abdomen, in all probability, with caudal appendages. "If these views are correct the genus *Campodea* must be regarded as "a form of remarkable interest since it is the living representative of "a primæval type from which not only the *Collembola* and *Thysanura*, "but the other great Orders of insects have derived their origin."

I have felt great reluctance in giving garbled extracts from the works of these eminent authorities, and venturing to allude to their opinions in so cursory a manner; but as some excuse for doing so I

[1] "Facts for Darwin" (translated from the German of Dr. Fritz Müller, by W. S. Dallas), Chap. xi., p. 120, 1876.

[2] "On the Origin and Metamorphoses of Insects," by Sir John Lubbock, Bart., M.P., F.R.S., Ch. v., p. 92, 1874.

[3] An existing genus belonging to the order *Thysanura*.

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would observe that it is not within the scope of this paper to discuss the questions of the probable origin and progressive development of insects from Biological data, but merely to call attention to such facts, bearing on the subject, as have been obtained by the researches of the Geologist and Palæontologist; which facts would, however, be scarcely intelligible in their application, without at least an allusion to some of the opinions, before quoted, on these questions.

It must be admitted that, up to the present, we have no record of the discovery in any rocks—even in the most ancient—of any forms of insects which are, *at first sight*, connecting links between existing types and simpler organisms. On this point Sir John Lubbock observes,[1] that "the earliest known *Neuroptera* and "*Orthoptera*, though in some respects less specialized than existing "forms, are as truly and as well characterized insects as any now "existing; nor are we acquainted with any earlier forms which in "any way tend to bridge over the gap between them and lower "groups, though, as we shall see, there are types[2] yet existing which "throw much light on the subject."

Even apart from the opinions of the distinguished Biologists before quoted, it would be unreasonable to suppose that the oldest known *Neuroptera* and *Orthoptera*—even though many of them are less specialized than existing forms—represent the earliest types of the Class to which they belong; and we may confidently expect that with the progress of Geological research in the Devonian, and very possibly in the Silurian[3] formations, traces of the former existence of winged insects, simpler in form, and even more generalized in structure than any yet discovered, may be brought to light.

Making due allowance for the comparative shortness and incompleteness[4] of the Geological record, the opinions of Biologists on

[1] "On the Origin and Metamorphoses of Insects," Ch. v., p. 86, *antea cit.*

[2] i.e. *Campodea*, referred to on the previous page.

[3] Remains of land plants have been discovered in rocks of Lower Silurian age.

[4] Mr. Darwin's remarks on this point are especially apt—"I look at the geological record as a history of the world imperfectly kept, and written in a changing dialect; of this history we possess the last volume alone, relating only to two or three countries. Of this volume only here and there a short chapter has been preserved; and of each page only here and there a few lines. Each word of the slowly changing language more or less different in the successive chapters, may represent the forms of life which are entombed in our consecutive formations, and which falsely appears to us to have been abruptly introduced." "The Origin of Species," by Charles Darwin, F.R.S., 6th edit., p. 289.

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the subject of the progressive development of the various Orders of insects, seem to be borne out by the results of such Palæontological researches as have yet been made ; and we find that the relative subordination of the existing groups is pretty much in accordance with the order of their Geological succession, the simpler forms preceding the more highly organized. Some of the oldest known insects were, as we have seen, much less specialized than those of the present day, and many of them combined peculiarities of structure now characteristic of separate Orders, such as combinations of characters of *Neuroptera* and *Orthoptera*, of *Neuroptera* and *Hemiptera*, or of *Neuroptera* proper and *Pseudo-Neuroptera*.

These synthetic types, however, were associated with representatives of the most recent forms, and even some of the Devonian Insects—the most ancient known—are, according to Mr. Scudder,[1] to be "referred with very little question not only to the *Neuroptera*, "but even to a particular family of *Neuroptera* now existing—the "May flies. Indeed, the presence, at the apparition of a given "group, of modern types side by side with those which elude our "classification of existing forms is one of the peculiar problems of "Palæontology."

Notwithstanding the occurrence of recent types in the most ancient rocks, the rule that the simpler forms precede the more highly organized, holds good in the main, the oldest *Neuroptera* being represented, almost invariably, by species with incomplete metamorphoses, and the oldest *Orthoptera* including—with the exception of a few *Phasmidæ* and *Gryllidæ*—hardly any species, except *Blattidæ*, which are more numerous than all the other Palæozoic Insects.

The great rarity of the remains of the *Hemiptera* and *Coleoptera* in the Palæozoic rocks prevents us from ascertaining whether they, like the *Neuroptera* and *Orthoptera*, were chiefly represented at this early period, by their lowest[2] families.

The scarcity of representatives of these two Orders in Palæozoic rocks can, I think, only be explained on the hypothesis that they

[1] "Mem. Bost. Soc. Nat. Hist.," Vol. iii., pt. 1, No. 2, 1879.

[2] Since writing this I have read Mr. Scudder's remarks on the Palæozoic *Hemiptera*, which are as follows:—"We may glean still another fact from the scanty data the rocks afford us concerning the early types of Insects. All the *Hemiptera* of the Palæozoic rocks belong to the *Homopterous* division of the sub-Order, indicating what is generally conceded, that this division is lower than the *Heteroptera*, which first appeared in the Jura." "Mem. Bost. Soc. Nat. Hist.," Vol. iii., pt. 1, No. 2, *antea cit.*

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made their appearance much later than the *Neuroptera* and *Orthoptera*; had they been fully developed at as early a period as the two Orders last named, their remains would certainly have been preserved at least as commonly as remains of those Orders. This is especially true of the *Coleoptera*, which, from the hardness of their elytra, are capable of preservation under much less favourable conditions than is requisite for the preservation of insects of most orders; and in the rocks of the Secondary and Tertiary Periods, fossils of this Order of Insects are, as a rule, far more abundant than those of any other Order of Insects.

As we have seen, only two species of *Coleoptera* are known from the Palæozoic rocks, and only three from the Trias; but from the Rhœtics several are recorded, and from the Lias great numbers have been obtained; and from this remote period to the present time the *Coleoptera* appears to have been a dominant Order, though, as previously observed, representatives of this class have, from their nature, doubtless been preserved in much greater numbers than insects of most Orders, and may thus appear to have been comparatively more abundant than they really were.

Returning to the *Hemiptera*—it will be remembered that only three species of this Order are recorded from the Carboniferous rocks, and two from the Permian. No species of this Order have yet been discovered in the Trias, but a few are recorded from the English Lias, and several from the Lias of Schambelen.

One or two supposed species of *Diptera*[1] are recorded from the English Lias, but no remains of this Order are known from any Continental formations older than the Solenhofen slate. Both this Order and the *Hymenoptera* appear to be sparingly represented in the Purbecks; but it is not until we reach the formations of the Tertiary age that we find either of them generally distributed or abundantly represented. As Prof. Heer observes—the date of the appearance of these Orders must have depended upon the state of development of the vegetable kingdom, and insects which resort to flowers for their nourishment, could not have existed prior to the period at which the dicotyledonous plants attained a high stage of perfection.

The most modern Order is apparently the *Lepidoptera*, no remains of which are recorded from any strata older than the Stonesfield

[1] Of one of them Prof. Westwood observes—"Seems like the body of a Tipulideous insect." Of another fragment he says, "May possibly be *Dipterous* allied to *Asilus*." Brodie's "Fossil Insects," p. 128.

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slate. From this formation, as I have already noticed in my second[1] paper, remains of two *Lepidopterous* (?) insects have been obtained, one of which has been described and figured by Mr. Butler in his "Lepidoptera Exotica" as *Paleontina Oolitica*. The question of whether or not this fossil should be referred to the *Lepidoptera*, or to the *Hemiptera* (*Homoptera*), having been discussed at some length in the paper last mentioned, I shall not further allude to it.

With the exceptions of *Paleontina Oolitica*, of two *Lepidopterous*[2] insects from the Solenhofen Slate, and the two very[3] doubtful fragments from the Purbecks, we have no record of the discovery of any well authenticated fossil insects of this Order from older strata than the upper division of the Lower Tertiaries. From formations of this period about twenty-six species of *Lepidoptera* (exclusive of those found in Amber), have been recorded, namely, four from strata of Upper Miocene age, eight from the Middle Miocene, four from the Lower Miocene, and ten (five *Rhopalocera*) from the Upper Eocene. Of these twenty-six species of *Lepidoptera*, ten have been referred to the *Rhopalocera* (or Butterflies), and the remaining sixteen to the *Heterocera* (or Moths).

Of the ten species of butterflies, five have, as I remarked in my first paper, been obtained from formations of the Upper Eocene period, but none have been recorded from older strata of the Tertiary Age.

From the evidence at present obtained by Palæontology, it appears that the *Neuroptera* is the oldest of the existing Orders; that it was followed by the *Orthoptera*, and that these two Orders included *almost all*[4] the insects of the Primary or Palæozoic period, towards the close of which the *Hemiptera* and *Coleoptera* began to appear; that comparatively early in the Secondary or Mesozoic Period, the two last named Orders became abundant and widely distributed, and somewhat later were followed by the *Diptera*, and some families of the *Hymenoptera;* and, further, that towards the close of this period other families of the *Hymen-*

[1] See "Proc. Geol. Assoc.," Vol. vi., No. 3; pp., 126 and 127. July, 1879.

[2] *Sphinx Snelleni* and *Pseudosirex Darwini*.

[3] *Cyllonianum Boisduvalianum* and *C. Hewitsonianum*.

[4] It must, of course, be understood that those ancient types, which, from their combination of the characters of two or more orders or families of insects, have been placed by Dr. Goldenberg in the extinct order *(Palæodictyoptera)* before referred to, are excepted from this generalization.

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optera—including the Bees—appeared, and were accompanied, or immediately followed, by the *Lepidoptera*, which last Order, however, does not appear to have been thoroughly established much before the close of the Eocene Division of the Tertiary Period.

In attempting to arrive at any conclusion as to the origin and evolution of Insects, and the order of their Geological succession, from a consideration of the facts derived from Palæontology, the shortness and incompleteness of the Geological record must always be borne in mind, and, as Mr. Darwin[1] remarks, "The crust "of the earth, with its embedded remains, must not be looked at "as a well filled Museum, but as a poor collection made at hazard, "and at rare intervals."

The force of these observations is especially felt in the particular branch of Palæontology which is the subject of these papers. Although, as we have seen, fossil insects have in certain strata, and in a few widely scattered localities, been obtained in considerable numbers, they appear to be, as a rule, extremely rare; and consequently afford but few data on which to base satisfactory generalizations as to their probable origin, order of succession, and geographical distribution in former ages.

The course of progression through which insects are considered by many Biologists to have attained to their present condition, and the primary relations of the various Orders, have been fully discussed by Sir John Lubbock,[2] Mr. Darwin,[3] Professor Haeckel,[4] Dr. Fritz Müller,[5] Dr. Packard,[6] Mr. Scudder,[7] and others.

The great antiquity of many of the existing genera of insects, as compared with that of the genera of the Vertebrates, and the very small amount of change[8] which has taken place in many of

[1] "The Origin of Species," Ch. xiv., p. 487 (1859).

[2] "On the Origin and Metamorphoses of Insects," *antea cit.*

[3] "The Origin of Species," *Antea cit.*

[4] See "The History of Creation" (an English translation of "Natürliche Schöpfungsgeschichte") by Dr. Ernst Haeckel, 1874; the translation revised by Prof. E. Ray Lankester, 1876.

[5] "Facts and Arguments for Darwin" (translated from the German, by W. S. Dallas, 1869).

[6] "Embryological Studies on Hexapodous Insects," Mem. Peabody Academy of Science, Vol. v., pt. 1, No. 3. "On Synthetic Types in Insects." Bost. Jourl. Nat. Hist., Vol. vii, 591-2; and "Guide to the Study of Insects," 1869.

[7] "The Early Types of Insects." Mem. Bost. Soc. Nat. Hist., Vol. iii., pt. 1, No. 2, 1879.

[8] "The general type of wing structure in insects has remained unaltered from the earliest times." See the paper last cited, p. 21.

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them during the Geological record, is very remarkable. The truth of this must be apparent to any one who compares a list of the fossil insects of any Period with a list of the fossils of almost any other Class of the Animal Kingdom, which existed during the same Period. If we take any Order of insects—say the *Coleoptera*—and enquire what families of that Order were represented in the "Purbecks," we shall find *Buprestidæ*, *Carabidæ*, *Curculionidæ*, *Chrysomelidæ*, *Elateridæ*, *Cantharidæ*, *Tenebrionidæ*, &c. Now all these are existing families, represented at the present day by a great number of species. In what other division of the Animal Kingdom —at any rate amongst the *Vertebrata*—should we find so many families which existed during any part of the Jurassic Period represented at the present day?

Compare the fossils of the English Lias with the existing Orders of the Animal Kingdom. It will be seen[1] that the insect remains of this period have been referred to species distributed amongst the *Carabidæ*, *Telephoridæ*, *Elateridæ*, *Curculionidæ*, *Chrysomelidæ*, *Blattidæ*, and *Gryllidæ*, all of which families are represented at the present day; but, with regard to the *Vertebrata*, where are the representatives at the present day of the Saurians, the flying lizards, and other gigantic reptiles of the Lias? "When we consider," says Mr. Alfred Russell Wallace,[2] "that almost the "only Vertebrata of this period (*i.e.*, the Lias), were huge Saurian "reptiles like the *Icthyosaurus*, *Plesiosaurus*, and *Dinosaurus*, with "the flying Pterodactyles, and that the great mass of our existing "genera, and even families of fish and reptiles, had almost certainly "not come into existence, we see at once that the types of insect "form are proportionately far more ancient. At this remote epoch "we find the chief family types (the genera of the time of Lin-"næus) pefectly differentiated and recognizable."

I will now endeavour to suggest a few of the most important conclusions bearing upon the land and fresh-water conditions of the Earth in former ages, which may be arrived at from a study of fossil insects.

From the fact that some insects are aquatic, and some terrestrial, and that some are carnivorous, some herbivorous and some pre-

[1] See list of species at the end of the 2nd paper. "Proc. Geol. Assoc.," Vol. vi., No. 3, July, 1879.

[2] "The Geographical Distribution of Animals," Vol. i., p. 167, 1876.

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daceous in their habits, it is evident that the prevalence of the remains of any group or family of animals of this Class, in a fossil state, furnishes an important clue to a knowledge of the land and fresh-water conditions of the Earth, and of its climate and vegetation during the period of their existence; and Sir Charles Lyell[1] has remarked "that if this Class of the Invertebrata were "not so rare and local, they might be more useful than even the "plants and shells in settling chronological points in geology."

Where we find aquatic insects fossilized in large numbers in any strata, we necessarily infer the presence of rivers or fresh-water lakes; and the discovery of the remains of numbers of herbivorous insects in any formation certainly implies the former prevalence of a more or less luxuriant vegetation.

Fossil insects also furnish some evidence as to the contemporaneous existence of other Classes of the Animal Kingdom; for instance—the discovery in the Swiss Lias of the remains of coprophagous beetles, whose representatives of the present day are found in the dung of cattle, leads to the inference of the contemporaneous existence of some species of Mammalia, even although no traces of them have been detected in that formation; and the Rev. P. B. Brodie observes that, "the presence of insects in "any formation shows that there must have been animals which "preyed upon them, remains of which have been discovered in the "Oolite (including therein the Purbecks), wherein we have insec- "tivorous mammals."

Finally, I would observe that the conclusions arrived at by Prof. Heer,[2] from a study of the fossil flora of Europe, as to the various changes of climate which the Continent has undergone in past ages, have been, to a great extent, confirmed by his subsequent examination of the fossil insects of Europe, and a comparison of their families, genera, and species, with those of the existing insect fauna and their geographical distribution.

[1] "Elements of Geology," 6th edit., p. 255.

[2] "Untersüchungen ueber das Klima und die Vegetations Verhaltnisse des Tertiärlandes." Winterthur, 1860. See also the French translation, by Dr. Gaudin, "Recherches sur le Climat et la Végétation du Pays Tertiaire." Paris, 1861.

[NOTE.—For list of Palæozoic Insects, see next page.]

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A LIST OF INSECT REMAINS DISCOVERED IN THE FORMATIONS OF THE PALÆOZOIC PERIOD.

EUROPE.

GREAT BRITAIN.

CARBONIFEROUS.

From the Ironstone of Coalbrook Dale, Shropshire.

ORTHOPTERA.

Gryllacris (Corydalis) Brongniarti.

COLEOPTERA

Curculioides Ansticii.

From the Coal Measures on the north bank of the Wear, opposite Claxheugh, near Sunderland.

ORTHOPTERA.

Phasmidæ? (supposed species of).

Blattidium mantidioides.[1]

From the Scottish Coal-fields in the neighbourhood of Glasgow.

ORTHOPTERA.

Lithomantis carbonarius.

CONTINENTAL EUROPE.

PERMIAN, OR DYAS.

From Schwarzenbach, Birkenfeld, Cassel.

PALÆODICTYOPTERA.

Eugereon Böckingi.

HEMIPTERA.

Fulgorina (Fulgora) Ebersi.

From Stockheim, Bavaria.

PALÆODICTYOPTERA.

Ephemerites Rückerti.

ORTHOPTERA.

Blattina Rückerti.[2]

From Weissig, Saxony.

ORTHOPTERA.

Blattina Weissigensis.[3] Blattina anthracophila (flabellata).[3]

„ porrecta.[4] „ carbonaria.[3]

„ didyma (sopita). „ Mahri.

1 Referred by Scudder to the genus *Etoblattina.*

2 „ „ „ *Anthracoblattina.*

3 „ „ „ *Etoblattina.*

4 „ „ „ *Anthracoblattina.*

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From Lebach, near Saarbrück in the Rhenish Provinces of Prussia.

ORTHOPTERA.

Blattina lebachensis.[1]
„ gracilis.[2]

HEMIPTERA.

Fulgorina (Fulgora) lebachensis.

CARBONIFEROUS.

From the neighbourhood of Saarbrück, in the Rhenish Provinces of Prussia.

PALÆODICTYOPTERA.

Dictyoneura libelluloides.
„ anthracophila.
„ formosa.
„ Decheni.
„ elegans.
Dictyoneura elongata.
„ Schmitzii.
„ obsoleta.
„ Humboldtiana.

NEUROPTERA.

Termes Heeri.
„ affinis.
„ Hageni.
„ Buchi.
Termes laxa.
Termitidium amissum.
„ rugosum.

ORTHOPTERA.

Gryllacris lithanthraca.
Acridites formosus.
„ carbonatus.
Blattina primæva.[3]
„ labachensis.[3]
„ insignis.[3]
„ winteriana.[4]
„ intermedia.[5]
Blattina scaberata.[5]
„ Wemmetsweileriensis.[6]
„ Remigii.[7]
„ weissiana.[8]
„ Tischbeini.
„ venosa.
Polyzosterites granosus.

HEMIPTERA.

Fulgorina (Fulgora) ebersi.
Fulgorina (Fulgora) klieveri.

COLEOPTERA.

Troxites Germari.

[1] Referred by Scudder to the genus *Hermatoblattina*.
[2] „ „ „ *Petrablattina*.
[3] Referred by Scudder in his recent paper in the "Mem. Bost. Soc. Nat. Hist.," Vol. iii., pt. 1, No. 3, to the genus *Etoblattina*.
[4] „ „ „ *Anthracoblattina*.
[5] „ „ „ *Gerablattina*.
[6] „ „ „ *Hermatoblattina*.
[7] „ „ „ *Anthracoblattina*.
[8] „ „ „ *Gerablattina*.

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From Manebach, near Ilmenau, in Saxe Weimar.

ORTHOPTERA.

Blattina didyma.[1]
„ Manebachensis.[1]
„ Goldenbergi[2]
„ clathrata.[2]
Blattina Mahri.[2]
„ Fritschii[3]
„ latinervis.

HEMIPTERA.

Macrophlebium Hollebeni.

From Wettin and Lobejün, Prussian Saxony.

ORTHOPTERA.

Blattina euglyptica.[4]
„ affinis.[4]
„ flabellata.[4]
„ anthracophila.[4]
„ Dorhnii.[4]
„ anaglyptica.[4]
Blattina carbonaria.[4]
„ didyma.[4]
„ russoma.[4]
„ leptophlebica.[4]
„ parvula.[4]

ORTHOPTERA.

Blattina spectabilis.[5]
„ Geinitzi.[6]
„ Münsteri.[6]
Blattina producta.[6]
„ Germari.[6]
„ reticulata.[7]

From Klein-Opitz, near Dresden, Saxony.

ORTHOPTERA.

Blattina Dresdensis.[8]

From Erbignon, Valais, Switzerland.

ORTHOPTERA.

Blattina helvetica.[9]

From Sars-Longchamps, Mons, Belgium.

PALÆODICTYOPTERA.

Omalia macroptera.

NEUROPTERA.

Breyeria Borinensis.
Termes ? (a supposed species of).

[1] Referred by Scudder in his recent paper in the "Mem. Bost. Soc. Nat. Hist.," Vol. iii., pt. 1, No. 3, to the genus *Etoblattina*.
[2] „ „ „ *Gerablattina*,
[3] „ „ „ *Progonoblattina*.
[4] „ „ „ *Etoblattina*.
[5] „ „ „ *Anthracoblattina*.
[6] „ „ „ *Gerablattina*.
[7] „ „ „ *Oryctoblattina*.
[8] „ „ „ *Anthracoblattina*.
[9] „ „ „ *Progonoblattina*.

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ORTHOPTERA.

Pachytylopsis Persenairei.

From Commentry, Allier, France.

ORTHOPTERA.

Protophasma Dumasii.

AMERICA.

CARBONIFEROUS.

From the neighbourhood of Sydney, Cape Breton.

PALÆODICTYOPTERA.

Haplophlebium Barnesii.

NEUROPTERA.

Libellula (?) carbonaria.

ORTHOPTERA.

Blattina Heeri.[1]
„ Bretonense.[1]
Blattina sepulta.

From Mazon Creek, and elsewhere, near Morris, Danville, and Colchester, Illinois.

PALÆODICTYOPTERA.

Paolia vetusta.

NEUROPTERA.

Miamia Bronsoni.[2]
„ Danæ.[2]
Megathentomum pustulatum.
Euephemerites simplex.
„ gigas.
Crestotes lapidea.
Hemeristia occidentalis.
Euephemerites affinis.
Termes contusus.

ORTHOPTERA.

Mantis ? (supposed species of).
Mylacris anthracophilum.
Lithomylacris simplex.

From Cannelton, Beaver Co., and Pittston, Luzerne Co., Pennsylvania.

NEUROPTERA.

Euephemerites primordialis.

[1] These two species have been re-described by Mr. Scudder in the paper before mentioned ("Mem. Bost. Soc. Nat. Hist.," Vol. iii.), and referred to the genus *Mylacris*.

[2] Both these species have been referred by Goldenberg to the extinct order *Palæodictyoptera*.

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ORTHOPTERA.

Archymylacris parallelum.
Mylacris Pennsylvanicum.
„ Mansfieldi.
Necymylacris heros.
„ lacoanum.
Lythomylacris angustum.
„ pittstonianum,
Etoblattina Lesquereuxii.
Blattina fascigera.[1]

From Frog Bayou, Arkansas.

ORTHOPTERA.

Blattina venusta.[2]

From Pictou, Nova Scotia.

ORTHOPTERA.

Mylacris acadicum.

From Tallmadge and Bellaire, Ohio.

ORTHOPTERA.

Archegogryllus priscus.
Gerablattina balteata.[3]

DEVONIAN.

From "Fern Ledges," near Carleton, St. John's, New Brunswick.

NEUROPTERA[4] AND PSEUDO-NEUROPTERA.

Xenoneura antiquorum.
Gerephemera simplex,
Platephemera antiqua.
Lithentomum Harttii.
Dyscritus vetustus.
Homothetus fossilis.

[1] Recently referred by Scudder to the genus *Gerablattina*.

[2] „ „ „ *Etoblattina*.

[3] A second specimen of this species is recorded by Scudder from Cassville, Western Virginia.

[4] These insects have been placed by Dr. Goldenberg in the extinct Order *Palæodictyoptera*; but Mr. Scudder considers Goldenberg to have "gone too far" in referring them to this Order.

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